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SMALL YACHT CONSTRUCTION AND RIGGING.

Small Yacht Construction and Rigging

By LINTON HOPE

Illustrated by Two Complete Designs and Numerous Diagrams and Details

FOREST AND STREAM PUBLISHING COMPANY
NEW YORK CITY
1903

Engine
VM

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INTRODUCTION

SO many amateurs nowadays understand the use of carpenters' tools, and have some knowledge of yacht designing, thanks to the late Dixon Kemp's admirable books, that I feel sure a few hints on practical boat and small yacht building will interest yachtsmen generally, and, I hope, be of some assistance to those who wish to try their hands at building their own boats. Boat-building is one of the most fascinating hobbies a man can take up, although it is scarcely likely that any amateur would care about spending several years acquiring the requisite skill to enable him to turn out the very highest class of rater work. If, however, he has some natural talent, patience and common sense, there is no reason why, with a little practice, he should not be able to build a vessel which will be a credit to him, and probably better than many of the so-called "cheap boats" which are turned out by some small firms. He must not, however, be discouraged if, at the beginning, he only spoils wood, and has to do the work over and over again till he can make a good job; and he should, therefore, before starting, make up his mind that he will do it right, even if he has to make a half a dozen fruitless attempts.

Introduction

The chief maxims to be borne in mind in boat-building are: (1) Be sure that all your measurements are correct. (2) Always work to a level l.w.l., and be sure the moulds are both square and plumb to this line. (3) Shore and stay your keel and moulds so that they cannot possibly move while the boat is being built. (4) Keep your tools sharp, and keep your wood dry.

Chief Maxims in Boat-building

There are two general types of small craft now in use,

Types

which may be classified as round-bottomed and hollow-bottomed boats. The first comprises the modern centre-plate and bulb-fin boats (many of which are nearly or quite flat); whilst the second class consists of the deeper-bodied seagoing cruisers, and linear raters built to the new Y. R. A. rules for 1901.

The first type will be the easier for the beginner to tackle, owing to the simpler form of the keel and sections, and also because the weights of the various parts are much less, in proportion to the size of the boat.

Centreboards

Under this head will come the 22 ft. c.b. sailing boat (Design No. 1), which will be the best to start with, as she has far less work in her than boats of the other type. She will make a good, useful sailing boat, either for the coast or river, and can also be used as a yacht's sailing cutter, if the deck be omitted.

Bulb-fin

This design could easily be altered to a bulb-fin instead of the plate shown. All that would be necessary for this purpose would be to place the centre-board case 1 ft. further forward, and to have a $\frac{3}{8}$-in. rectangular plate dropped 2 ft. below the keel of the boat, with a cigar-shaped lead bulb of about 3 cwt. The plate and bulb would be raised by means of two bicycle chains running over sprocket wheels, which would both be carried on a single fore-and-aft shaft at one side of the centre case, this shaft being actuated by worm-wheel gear. The total amount of lift of the plate would be only 1 ft. 6 in., as the bulb could not be housed. The total draught of the boat, therefore, would be increased to 6 in. more than that shown in the design. If this amount of draught is too great, then I would advise a similarly shaped plate, built of two $\frac{3}{16}$-in. steel plates, riveted to a frame at the bottom and ends, and the intermediate space of, say, 1 in. filled in with lead to the required weight. This, however, is a much more expensive method of ballasting, and requires a very large slot in the keel, but has the advantage of housing completely. In either form, the centre-board case

must be made of such a height as to admit of the sprockets and spindle being fixed to the top of the case, and at the same time be high enough to allow the plate to house. Of course, the plate and bicycle chains and all iron work must be galvanized, and the chain would probably have to be specially made to suit. If a bronze plate were adopted, a chain could be used of the same material, which would be far better than the galvanized steel, but would cost considerably more. In no case should iron and yellow metal be used together. The bronze plate would have the further advantage of not creating galvanic action with the lead bulb. The exposed area of this ballast-plate must be slightly in excess of that of the centre-plate shown in the drawings, as, being shallower, it will be a less effective form.

Bulb-fin

The 24 l.r. fast cruiser (Design No. 2) complies with the new Y. R. A. rules. She will be more difficult to build, and should not be attempted at first.

All the round or flat-bottomed centre-plate boats should be built bottom up, as it is much easier to get at the work, and the builder can see at once if he is making a good job of the seams, besides being able to fair the moulds better when setting up the frame.

Methods of Building

The second type, or hollow-bottomed boats, are a bit more troublesome, as the keel, stem and stern frame have a good deal of work in them. The planking, too, especially about the garboards, and just at the tuck of the counter, is rather trying to one's patience at first.

These boats are usually built in the old-fashioned way, right side up, the bottom being easier to get at when this way up than that of a round-bottomed boat. They would also be very awkward to turn over when they get larger, both as to shape and weight. The 24 l.r. fast cruiser, for instance, would require ten or a dozen men to turn her over safely.

The designs shown are taken, not so much as being ideal

boats in any way, but chiefly as representing popular types of sailing boats and small yachts now in general use, and suitable for an amateur to build.

They will also be sufficiently typical to illustrate the methods used for most carvel-built boats up to ten tons.

The first three chapters will apply to all sorts of carvel building, but in the subsequent chapters I shall endeavor to explain the construction of a boat of each type side by side.

Small Yacht Construction and Rigging.

PART I.—BUILDING.

CHAPTER I.

Tools.

TO turn out good work it is absolutely essential to have a set of good tools, which must always be kept in proper order, though I know by my own experience that one does not care about the drudgery of sharpening them the moment they get the least bit blunt. If, however, they are allowed to get blunt and gapped, it is quite impossible to make a good job.

A common fault with amateurs' tools is that they are sharpened only on an oil stone long after they should have been ground, and the consequence is that the cutting angle gets steeper, and, though the actual edge is sharp, yet it is so steep that it will not make a clear cut. The following diagrams show a section of the edge of a chisel—A as it should be, and B as it should not be, but often is. (*See Cuts A and B on page* 14.)

Sharpening Tools

I do not propose to teach the use of the tools, as there are many excellent books on the subject, but I will give a list of the various tools requisite for the work before us, and also

some extra tools which, though not absolutely necessary, are exceedingly useful, if the expense is not too great; these are marked with an asterisk.

A B

Cost of Tools

The total cost of all the tools which are really necessary will come to about $25, not including the cost of a bench.

List of Tools

List of Tools.

1 half rip saw.
*1 fine panel saw.
1 turning saw, with 2 extra blades of different sizes.
*1 small compass saw, with half a dozen spare blades.
1 medium-sized tenon saw, with fine teeth.
1 jack plane.
1 smoothing plane (wood).
*1 smoothing plane (iron), with various adjustments.
1 rabbet plane.
1 $\frac{3}{8}$" round plane, for working hollow for gold line.
*1 3" circle, spar maker's hollow plane.
*1 $1\frac{1}{2}$" firmer chisel.
1 1" "
*1 $\frac{3}{4}$" "
1 $\frac{1}{2}$" " (This may be a dovetail chisel.)
1 $\frac{1}{4}$" firmer chisel.
1 $\frac{3}{4}$" inside bevel gouge, medium sweep.
1 small shipwright's adze.
1 draw knife.
1 spokeshave, with adjustable mouth.
1 ratchet stock and set of bits.
*1 set of pat. twist bits, $\frac{3}{16}$" to 1".
1 Archimedean stock and set of boat-builder's piercers.
1 set of four gimlets.
1 set of four bradawls.
2 screwdrivers, large and small.
2 hammers, a 2-lb. engineer's ball-pened hammer, and a light boat-builder's riveting hammer.
*1 "holder-on," or small maul head.
1 rooving punch.

List of Tools

1 carpenter's punch.
*1 pair stout pliers.
1 pair cutters.
1 pair pincers.
1 large vise.
*1 hack saw.
1 cold chisel.
1 10″ bastard file (flat safe edge).
*1 10″ bastard file (half round).
*1 6″ saw file.
*1 8″ round or rat-tail file.
*1 10″ smooth file (half round).
*1 Brest drill and a set of Morse twist drills.
*1 small anvil.
*1 hand vise.
1 12″ square.
1 2-ft. two-fold rule with slide.
1 bevel.
1 spirit level.
1 marking gauge.
*1 pair dividers with set screw.
2 plumb lines.
1 chalk line.
1 good-sized oil stone and a slip for the gouge, etc.
1 grindstone and stand, etc., for foot power.
*1 30-ft. steel tape (if possible marked in inches on one side and decimals of a foot on the other).
2 12″ stout iron cramps.
4 9″ light iron cramps.
2 or 3 paint and varnish brushes and a putty knife.
2 small caulking irons.
1 caulking mallet.
1 steam chest and boiler.

Work-bench

In addition to these tools, a really good firm bench should be made, long enough to take the longest planks which will be used, say 25 ft. long and 2 ft. wide, with the top of not less than 1½ in. fir, and *quite flat*. A wooden bench-vise should be fitted at the left-hand end, and the large iron vise fitted at the other end, so that very long stuff may be held in both. A flush rising and falling planing stop should be fixed in the top at the left-hand end, and some tool racks and drawers will be very handy; also a nail box or two.

Steam Chest

NOTE.—The steam chest can be made of four 9-in. by 1½-in. fir planks rabbeted at joints and well screwed together, with one end permanently blocked up and the other end fitted with a loose plug or door. The boiler may be any sort of kitchen

Steam Chest

copper or even a large kettle capable of holding two or three gallons. The lid must be made steam tight, and a pipe fitted from the boiler to the steam chest. A good plan is to fit one or two small bars across the steam chest inside, about half way up, so as to keep the wood to be steamed off the bottom, and let the steam get all round it. All the joints can be made sufficiently steam tight with red lead and canvas. A couple of good stout sawing horses or trestles must also be made.

CHAPTER II.

MATERIALS.

HAVING got the tools and bench, and a suitable workshop or building shed, the next thing is to get the necessary timber, nails and other material.

Without going into the question of the exact quantities required for building either of these proposed boats, it will be as well to consider the qualities of the various woods most suitable for the work. These are: **Materials**

Keel. English oak or American elm; pitch pine, mahogany, and English elm are all used at times, but are not so good as the first two.

Stem, knees, stern post and counter frame. English oak, grown to shape required. Steel knees may be used in place of oak.

Shelf or inwale and bilge stringers. American elm, mahogany, pitch pine or Oregon pine.

Bent timbers. American elm.

Floor frames. English oak crooks, unless they are steel forgings (rectangular or angle bars, well galvanized).

Deck beams and carlines. Oak, Oregon pine or Kauri pine.

Transom and centre case. Teak, mahogany or Kauri pine.

Planking. Teak, mahogany, American elm, cedar, Kauri pine, American spruce, red pine, white pine, larch or elm.

Deck. Cedar, yellow pine, Kauri pine or Oregon spruce.

Coamings. American elm, mahogany or teak.

Materials

Spars. Spruce sticks, bamboos or hollow spars.

Oak should be English grown and winter cut, with a fine close grain, as nearly as possible following the required curve. Avoid open-grained, reddish-colored oak, and, of course, see that it is well seasoned and *free from sap.*

American or Canadian Elm should be as *white* as possible and with hardly any grain showing and quite clear of knots and shakes. Avoid dark brownish wood.

Teak is the best and most durable wood for planking and all sorts of deck fittings, such as cabin tops, skylights, etc., as it is less affected by weather than any of the other woods named. It should be slightly greenish in color when first cut, with a fairly strongly marked grain. The lighter colored red teak is not quite so heavy, but is not so strong or durable.

The only objection to teak planking is its great weight, which quite bars it from use in racing craft. It can be easily obtained up to 40 or 50 ft.

Mahogany. There are many varieties. Honduras is the best; it should be fairly light in color and fine clear-grained. It stands weather well, is lighter than teak and at the same time fairly tough, and can be got up to 35 and 40 ft. long by 2 ft. wide.

Cedar is the principal wood in use for planking racing boats, as, for its strength and durability, it is the lightest wood in the market, and, like mahogany, is very long and wide. It stands the weather better than pine, and is as easy to work as yellow pine.

As a rule the light-colored cedars are lighter in weight than the dark red, but, though softer and easier to work, they absorb more water and lose their color very soon when varnished.

Pitch Pine is a very unpleasant wood to work, being full of resin, which clogs the tools very quickly. It is very durable and tough, but rather heavy. Pick it as light-colored and clear-grained as possible. Materials

Oregon Pine. A similar wood to pitch pine, but lighter both in color and weight, and not so durable. Still, it is so much tougher for its weight that it is better for boat work, and can be obtained almost any size.

Kauri Pine. A very durable wood for decks and planking, but rather heavy and not very tough for its weight compared with mahogany. It is fairly cheap and very wide, but rather difficult to get in long lengths, unless a whole log is bought.

Yellow Pine is very light and soft wood, with little strength, but is the wood most frequently used for decks, as it is easy to obtain in long lengths clear of knots and discolorations; it is very white when scrubbed. It should show little or no grain.

American Spruce is also a light, soft wood, but though not so clear of grain, is far tougher than yellow pine, and is more suitable for planking and small spars; it can be got up to 35 ft. by 12 to 15 in. wide, and comes in planks as a rule.

Archangel Pine or Spruce is not so clear as either of the last two, but is good enough for flooring and lining in plain jobs, or for a deck which is to be covered with canvas.

Larch is a very strong wood, with a lot of grain, and very good for planking, but hard to get in the south of England; it is durable.

Ash is the toughest English wood used in boat-building, and is almost equal to American elm, but not quite so supple or durable. It should be white, without any very dark grain.

English Elm may be used under water for very heavy keels, deadwoods and bottom planking, but it rots very quickly

between wind and water, and is a coarse-grained, common wood. The light-colored wych elm is the best, but difficult to obtain. Be careful of rotten and sappy patches, which often go half way through a log.

Materials

NOTE.—The woods mentioned in the foregoing chapter are those which are used in the construction of yachts in England. In America it is customary to use white oak for keel, stem, knees, stern post and frames. The shelf or inwale and bilge stringers are, as a rule, made of Georgia pine, although oak is occasionally selected. The reason for this is because Georgia pine can be procured in longer lengths than oak. In boats of light construction the frames or bent timbers are generally made of white oak; sometimes elm is used. Heretofore oak has also been the material of which the floor frames were built, but now steel is often used. Deck beams have always been made of oak because of its great strength, but for light work spruce answers every purpose. For planking Georgia pine is more desirable than any other wood, but for lighter construction cedar and mahogany are chosen. Teak is seldom used for planking, although it is surely gaining a foothold for deck finish on high grade work. In the case of double planking the inner skin is generally made of white pine while the outer one is of mahogany. White pine is almost always used for decks, whether they are to be covered with canvas or finished bright. Oak, mahogany, and occasionally teak, are used for coamings. Spars, either hollow or solid, are made of spruce, except in the larger vessels, when Oregon pine is used.

NAILS AND SCREWS, ETC.—A good stock of flat-headed copper boat nails will be required; say, 10 lbs. of 1¼ in. by 14 gauge, for planking and deck; 5 lbs. 2 in. by 12 gauge and 5

lbs. 3 in. by 12 gauge, for floors and knees; a couple of pounds of 4 in. by 12 gauge and 4 in. by 10 gauge, for heavy stem and stern fastenings, and 2 lbs. of fine ¾ in. scarph nails; all these nails should have suitable roves or burrs; 1 gross each of 4 in., 2 in., 1½ in., 1 in. and ¾ in. brass screws will be handy for the centre case and various internal fittings; they should be fairly stout. **Materials**

Copper rod will be required for bolting the stem and keel, scarph, etc., and should be ⅜ in., ¼ in. and $\frac{3}{16}$ in., with suitable rings to clench it on.

Caulking Cotton. Half a dozen balls will be enough to do a boat's planking and deck.

Paint, Etc. A stock of red and white lead, putty and paint will be wanted; but the paint should not be got till the boat is nearly ready for it; it should be of the best quality and well strained. A good priming for painting under the scarphs and in joints may be made of equal parts of red and white lead and boiled linseed oil as thick as cream.

To estimate the quantities of timber required for either of the two boats, proceed as follows:

Keel, stem and stern frame, etc. Get natural crooks to suit the shape of the templates, and of sufficient thickness to give the required siding and moulding. The keel for the No. 1 design is cut out of an American elm plank of the required thickness, and bent to the shape shown after it is cut out, so that it is only necessary to get a plank of the required length, breadth and depth. This also applies to the shelf and stringers, which can be bought ready sawn to the right section, and should be about 2 ft. longer than the over-all length of the boat.

In estimating the amount of planking required, take the number of planks aside, at the mid-section, and get a similar number of planks of the wood which has been decided on, each plank being about three times the width of a finished plank. Then, say there are seven planks a side, there will be seven

Materials.

large planks out of each of which two finished planks may be cut. The rough planking should be $\frac{1}{16}$ in. or $\frac{3}{32}$ in. thicker than it is to finish. For the deck, it is best to set out the planks on the deck plan, and then estimate the lengths required. The bent timbers must be counted, and the length of the *longest* taken, then get the requisite number cut to the required size and length. Deck beams are estimated by counting them and getting sufficient planking of the required thickness to cut them out, allowing for the curve; the wider the plank the less waste, as they cut one out of the other.

CHAPTER III.

Laying Off, Making the Moulds and Setting up the Frame.

WITH the required materials all ready for a start, the first thing to be done is to lay off the design full size on the floor. If, however, the workshop has not a boarded floor, it is quite possible to work without laying off the whole design, and only lay off the body plan and the profile of the stem on a large sheet of paper for the 22 ft. centre-board boat.

In the case of boats of the hollow-bottomed fixed keel type, a full-sized drawing of the whole profile, from stem head to the end of the counter, should be laid off, and if the workshop has no boarded floor, some long, clean floor boards must be clamped together to make a temporary mould floor; but we will suppose there is a suitable floor. **Mould Floor**

When laying off full size, start with the l.w.l. as the main base line, from which all vertical measurements are taken, and the fore and aft centre line for setting off the half breadths. Then rule the floor or board to exactly correspond with the design from which you are working. This is done by setting off all the distances of the water lines, buttocks and diagonals from the centre and stretching a chalked cord from one end of a line to the other and then pulling it up in the middle and letting it snap on the floor, leaving a clean line which is perfectly straight and can be penciled in. Be sure all your lines are parallel to one another and that you have not mistaken decimals for inches. Decimals are generally used throughout **Laying Off**

the *design,* but inches would be used in the *construction* drawing.

Laying Off Body Plan

The floor being ruled to correspond with the design, start with the body plan. Set off half-breadths of the mid-section along each horizontal line from the vertical centre line, taking the utmost care that the distances are absolutely correct. Then mark the vertical distance on the centre line for the bottom of the keel, below the l.w.l., the height of the deck above l.w.l. at the half-breadth on deck, and the vertical heights above or depths below the l.w.l. where the section crossed each buttock line. The diagonals are set off by taking the distances from where they intersect the centre vertical line to the points where they intersect each section on the body plan.

Having set off all these points, a thin, flexible batten should be bent so as to pass through all the spots, and is kept in position by some wire nails till a clear line has been drawn round the whole section. From this line a parallel line is drawn round it, exactly the thickness of the planking to be used; the other sections are drawn in the same manner. Then the sheer and profile are taken from these sections and checked by the design. In small boats it is not really necessary to lay off the half-breadth plan, as well as the sheer and body plans, but, of course, it helps toward accuracy, and is always done in the case of larger vessels.

Laying Off Sheer and Profile

To lay off the correct shape of a transom when it is not perpendicular to the l.w.l.:

Laying Off the Transom

Use the line of the transom on the *sheer* plan as a centre line, and set off the half-breadths on deck and l.w.l. at *right angles* to this new centre line, from their points of intersection with it on the sheer plan.

The line of the transom should be produced downward till it cuts l.w.l. and all heights above l.w.l. marked on this line, taking them *perpendicular to l.w.l.,* and setting off their distances from the centre line at *right angles* to the *line of the*

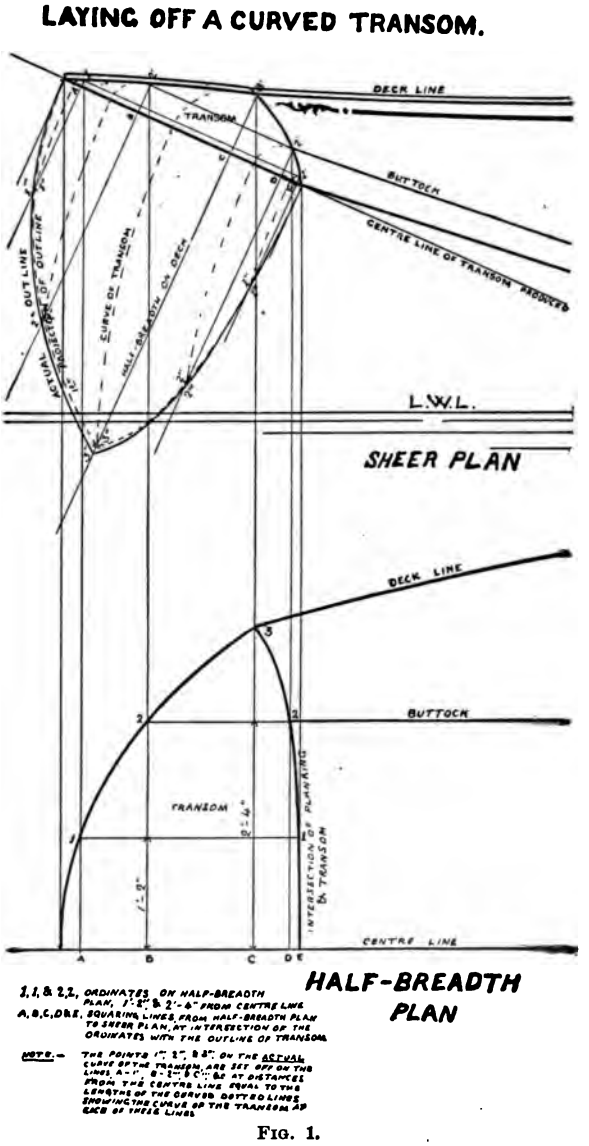

LAYING OFF A CURVED TRANSOM.
DECK LINE
TRANSOM
BUTTOCK
CENTRE LINE OF TRANSOM REVOLVED
ACTUAL SECTION OF OUTLINE
CURVE OF TRANSOM
HALF-BREADTH OF DECK
L.W.L.
SHEER PLAN
DECK LINE
BUTTOCK
TRANSOM
INTERSECTION OF PLANKING & TRANSOM
CENTRE LINE
A
B
C
D E
HALF-BREADTH PLAN
1,1, & 2,2, ORDINATES ON HALF-BREADTH PLAN, 1'-8" & 2'-6" FROM CENTRE LINE
A,B,C,D&E, SQUARING LINES FROM HALF-BREADTH PLAN TO SHEER PLAN, AT INTERSECTION OF THE ORDINATES WITH THE OUTLINE OF TRANSOM
NOTE.— THE POINTS 1", 2", & 3", ON THE ACTUAL CURVE OF THE TRANSOM, ARE SET OFF ON THE LINES A-1", B-2", & C-3", AT DISTANCES FROM THE CENTRE LINE EQUAL TO THE LENGTHS OF THE CURVED DOTTED LINES, SHOWING THE CURVE OF THE TRANSOM AT EACH OF THESE LINES

FIG. 1.

Laying Off a Transom

transom from the point of intersection of the heights above l.w.l.

If the transom is curved as well as raked, as in No. 2,

it is usually laid off in the foregoing manner first, but such a drawing only gives the shape as if it had no curve, all the half-breadth being incorrect.

Laying Off a Curved Transom

To get a true drawing of it from this, a section of the curve must be shown forming a plan, of which the first drawing is an elevation.

To obtain this section of the curve, take the distance, at right angles from the centre line of the transom on the sheer plan, to where the transom and planking meet at the deck. This is the depth of the curve, and must be set off on the

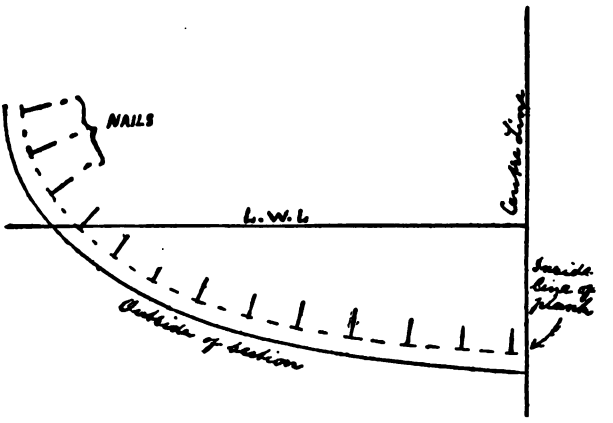


FIG. 2.

centre line of the transom, from the point of intersection of the half-breadth line of the deck, and the curve drawn through this point and the half-breadth, set off at right angles to the centre line. (*See Fig.* 1.)

Making the Moulds

The moulds should be made of some common floor boards or any cheap wood, about $\frac{3}{4}$ in. or 1 in. thick, and to transfer the exact shape of the section to the board, it is usual to lay a row of tacks or nails with their heads along the line of the inside of the plank on the section. (*See Fig.* 2.)

The object of the nails is, that when the piece of board

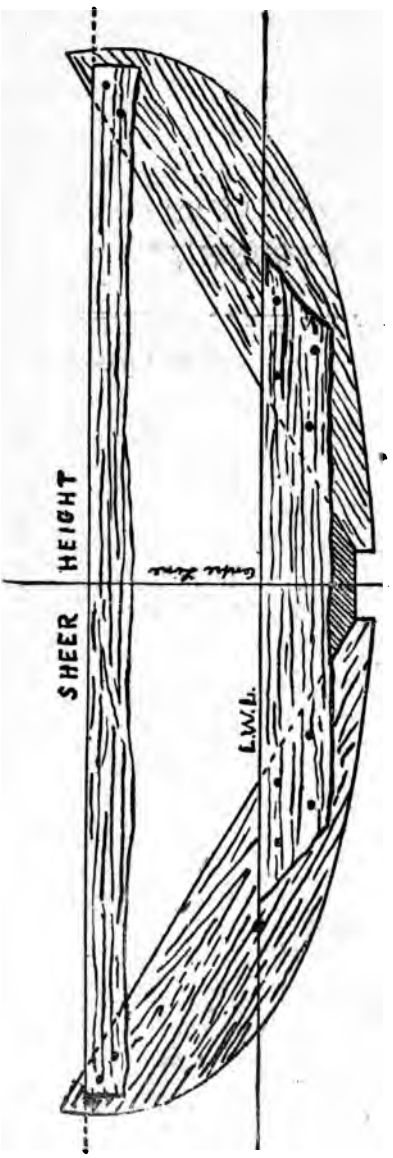


FIG. 3

to be used for the mould is placed over the nails and tapped all over with a mallet, the heads of the nails are driven half into the drawing on the floor, and half into the wood for the mould,

leaving a clear print of dents all round the curve, which is quite enough guide to saw it out by. Now saw out the rough shape of the section in duplicate, and then carefully fit it to the curve of the section till it is exact. Mark the l.w.l. centre line, and sheer height of the deck edge on each half, and fasten them together with two cross battens at the l.w.l. and deck level. (*See Fig.* 3.)

Finishing the Mould

Then cut out the section of the keel at that station so as to let the mould fit over the keel to its proper depth; that is to say, till it is flush with the rabbet in the keel, but don't cut it too big at first. Be sure and take the greatest care that each mould is accurate, and that the centre line is square with the l.w.l. and sheer line on it; also number each mould as you finish it.

Shaping the Stem

When the moulds are finished, make a thin wooden pattern, or template, of the stem from the full-sized drawing on the floor, in the same way as the moulds, and lay it on a suitable piece of crooked oak, drawing a pencil all round it to mark the curve of the moulding or depth. Saw a little outside the line so as to have a bit of spare wood for trimming up with plane and spokeshave. Cut the scarph as accurately as possible, and square it carefully.

Get out similar templates for the keel and stern frame (for No. 2 design, or the transom knee for No. 1 design) in the same way, and prepare the wood as before, in all cases marking the centre line along both top and bottom when finished.

Marking Out the Keel

The keel should now have the stations for the moulds marked accurately on it, measuring from the construction sheer plan, and taking the distances along the *top edge of the keel* on the drawing (not the horizontal spacing of the sections). At each of these stations set off the half-breadth on each side of the centre line, as shown in the half-breadth drawing of the keel and stern, etc. A batten should be bent through these spots and a fair line drawn through them from end to end of

the keel, which may now be cut out a little larger than this line and then planed up ready for setting up and scarphing to the stem, etc.

Fit the scarph between keel and stem, painting between the two, and bolting them together with about four ¼ in. copper **Riveting Keel and Stem**

FIG. 4.

bolts, clenched inside on copper rings. These bolts can be made in a few minutes in the vise, by cutting off pieces of the ¼ in. copper rod about an inch longer than the total thickness of wood, and making a good head on one end with the small riveting hammer. (*See Fig.* 4.) The other end should be

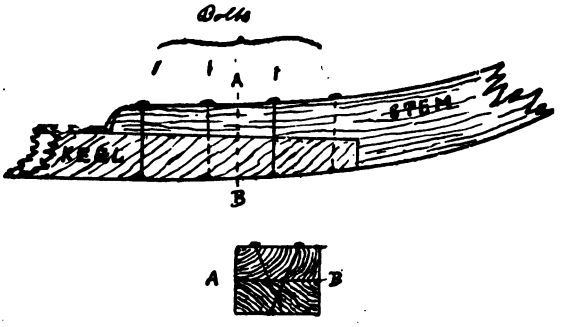


FIG. 5.

slightly pointed, and the bolt carefully driven, fairly tight; but the hole must not be bored too small, or the bolt will bend in driving. Be careful not to get the holes much out of the centre line on the *outside* of the scarph, but cant them to each side alternately on the inside (as in *Fig.* 5), and punch the heads in to the keel.

The transom of the centre-board boat should be cut out in the same manner as a mould, but from a single piece of ma- **Cutting the Transom**

hogany $\frac{3}{4}$ in. thick. It must be carefully planed up and fitted to the drawing on the floor, and cut with about $\frac{1}{4}$ in. bevel on the edges, so that the *inside* is $\frac{1}{4}$ in. larger all round than the drawing. It should be, at least, 3 in. higher than the deck-level to allow for trimming up afterward, and also to fasten the shores. Fit it over the end of the keel, like the moulds; but in this case the joint must be watertight. The transom knee is bolted to the keel with three $\frac{3}{16}$ in. bolts, similar to those in the stem scarph, the joint being painted first. The transom should be fastened to the knee with three stout 2 in. copper nails or screws; it must be perfectly square with the keel and its centre line plumb with the stem. Cut the slot for

Making the Transom

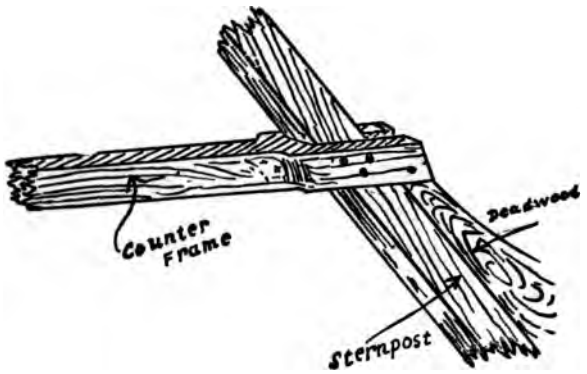


FIG. 6.

the centre-board in the keel, and also the rabbets along each side of it for the sides of the case. Before setting up the keel in its place these rabbets must be very carefully finished to the section shown.

Cutting Centreboard Slot and Rabbets

In the case of the fixed keel boat (No. 2) the keel should be set out from the body plan and half-breadth, and bolted to the stem as before, but, instead of a transom and knee on the after end of the keel, there is a stern-post and counter-frame, or horn timber. (*See Fig.* 6.) The stern-post should be cut out according to the drawings and specification, and

scarphed to the keel by cutting away half the keel and half the stern-post where they cross, and securing them by four $\frac{3}{16}$ in. bolts. When the stern-post and keel are properly scarphed and fastened, the dead wood must be roughly cut to the thickness of its largest part and fitted to the angle of the keel and stern-post, and well bolted with $\frac{3}{8}$ in. bolts, as shown in *Fig. 7.*

Fitting Stern-post and Deadwoods for No. 2 Boat

Trim it roughly with the adze to the thickness of the stern-post on its after edge, and to the keel at the bottom, but leave the full thickness along the top till the moulds are up. See that the stern-post and stem are both plumb with each

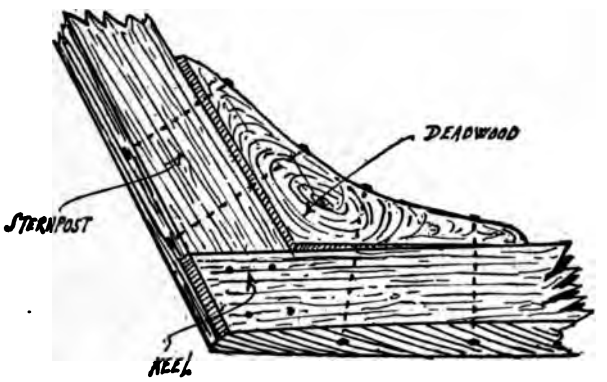


FIG. 7.

other, and not one over to port and the other to starboard, as often happens at first.

Cut out the counter frame to the moulding and siding given in the drawing, and cut the inner end carefully to fit round the stern-post, to which it must be well bolted by two or three $\frac{1}{4}$ in. bolts, but make sure the angles of it and the stern-post are right, by laying a rough template of keel, stern-post, and counter-frame, against the frame when it is ready to bolt together.

Fitting Counter Frame

It is easier to fit the rudder trunk, or case, now than it will be after the boat is planked, as would be the procedure

with larger craft. This is made like a box with two 1 in. mahogany or Kauri pine planks on each side of the stern-post, with a 1½ in. centre-piece on the after side. The latter is rabbeted into the two sides, and all three are rabbeted into the counter-frame. (*See Fig.* 8.)

Fitting Rudder Trunk

All the joints, like the scarphs of the stem and stern-post, etc., must be well fitted and painted with thick red and white lead before bolting together.

Both boats' keels and frames are now ready to set up, but

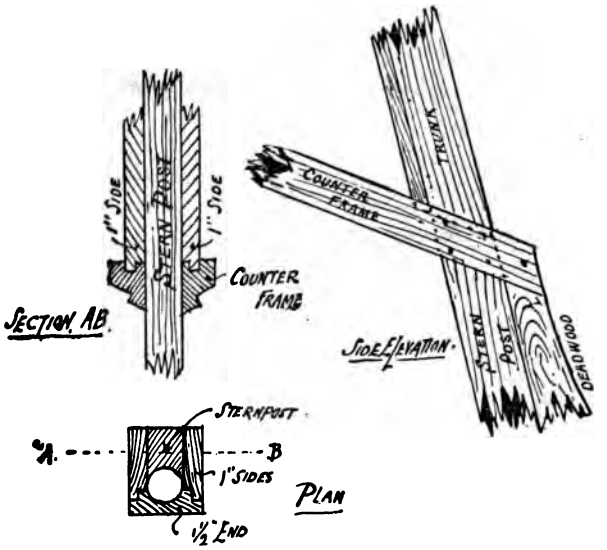


FIG. 8.

they will be treated in different ways, as the centre-boarder will be built bottom up, and the keel boat keel downwards.

Setting Up the Moulds

Starting with the centre-boarder, draw a central chalk line on the floor and mark all the sections. Then set up the midship section exactly square with the central line, so that the keel will be about 3 ft. above it, using the plumb line to make sure the centre line of the mould is vertical and right over the line on the floor. Fix the mould in place with a

centre post, which should be fixed to the mould so that one edge is on the centre line. This post must be nailed to a cleat on the floor and well stayed fore and aft to keep in a vertical position. Two side posts will be necessary to keep the mould level. (*See Fig.* 9.)

Bracing the Mould

The exact distance apart from centre to centre of the moulds should now be checked along the centre floor line and the height of the l.w.l. on the midship mould noted, as all the other moulds must be levelled to this height above the floor. They will all be set up in the foregoing manner and well stayed fore and aft, so that they are square with the centre floor line, their vertical centre lines plumb, and l.w.l.'s level. This is a

Spacing the Moulds

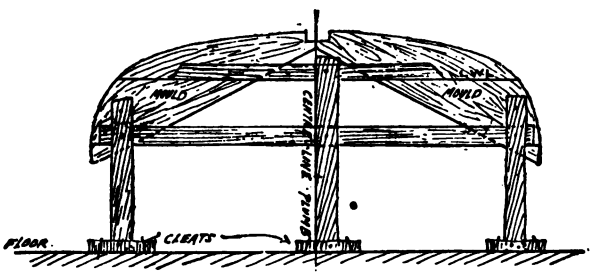


FIG. 9.

long and tedious business, but on its accuracy all the rest of the work depends, so do not stint a little extra care and time over it, and fix them so that they will not move when you come to work on them.

Work to the fore edge of the moulds forward of, and including the midship section, and to the after edge of the others; that is to say, place the forward moulds so that the mark for their places on the central floor line comes just on the fore side of each, and on the after side of the after moulds. The object of this is to avoid bevels on the edges of the moulds, which would be required if the centre of each were taken instead of the edge, as shown by the sketch. (*See Fig.* 10.)

Placing Mould to Avoid Bevel

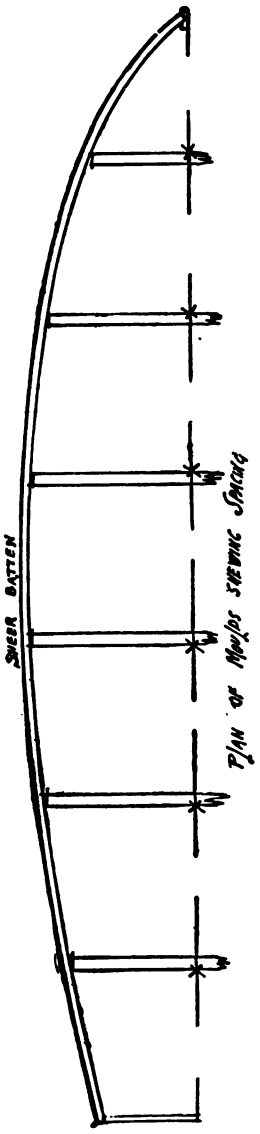

SHEER BATTEN
PLAN OF MOULDS SHEWING SPACING

FIG. 10.

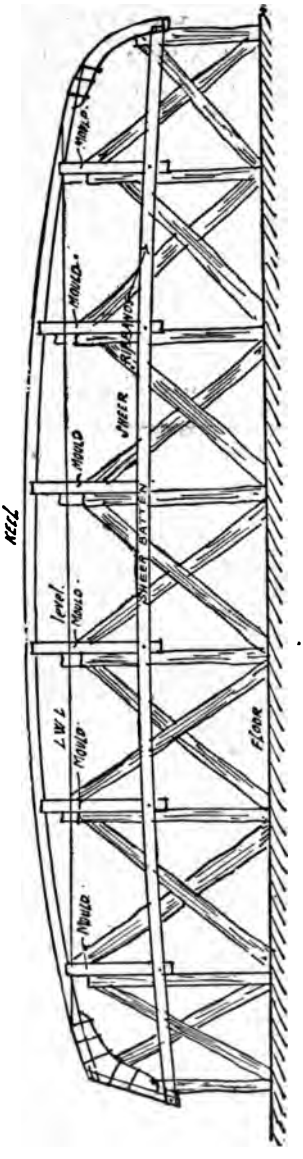

KEEL
MOULD
SHEER BATTEN
LWL
FLOOR
ELEVATION OF CENTRE BOARD BOAT IN FRAME.

FIG. 11.

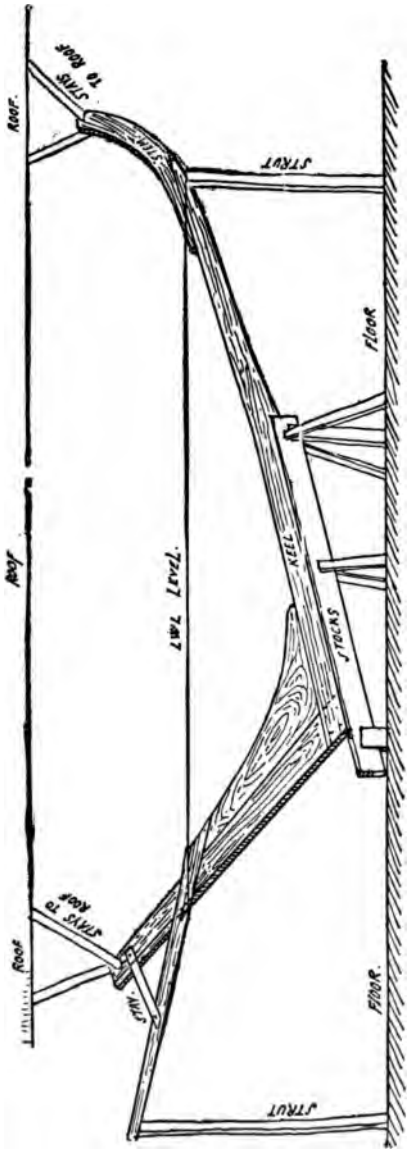


FIG. 12.

Checking the Moulds

Check the squaring of the moulds by measuring from the centre of the stem to the outside of the first mould at the sheer level on each side and see they are the same, then do this between each pair of moulds till all are exact.

Placing the Keel

The moulds are now ready for the keel to be bent over them and screwed to each; when it is seen to be fair and correct to the curve of the drawing, the stem and transom must then be stayed in a similar manner to the moulds, squaring and plumbing from the central floor line as before, and a line should be stretched through all the moulds at the l.w.l., and carefully levelled. A sheer batten should be nailed round the moulds at the deck level to fair them and hold them in place while the rabbet is cut. (*See Fig.* 11.)

Placing Sheer Batten

The moulds for the keel boat will not be set up first, but after the keel and frame are set up in place on the stocks, and fixed by shores and stays from the roof and walls. The stocks are best made from a 3 in. by 9 in. deal on edge, firmly fixed to the floor at exactly the same angle as the keel. (*See Fig.* 12.)

Setting Up Keel Boat

When the frame is fixed, a clear centre-line must be marked along keel, stem, stern-post, and counter-frame, and the stations for the moulds marked on it in the same manner as on the floor line in the case of the centre-board boat. The moulds can now be set up as before, except that they are now right way up and stayed from the roof; or if that is too high, a fore and aft 3 in. by 9 in. deal must be fixed from stem to stern, and well secured to the roof and walls, and the moulds stayed from that.

The moulds being fixed square and plumb in their proper places and the sheer batten on, the rabbet should be cut.

CHAPTER IV.

CUTTING THE RABBET AND FAIRING THE MOULDS.

IT is a common practice for professional builders to cut most of the rabbet of centre-board boats before the keel and stem are set up in place, as it is much easier to get at the work when they are in separate pieces, which can be easily moved into the most convenient positions for working. **Cutting the Rabbet**

This method, however, requires considerable knowledge of the trade before it can safely be attempted; and, though entailing more work, it is consequently much safer for the amateur to cut the rabbet after the whole frame is set up and properly

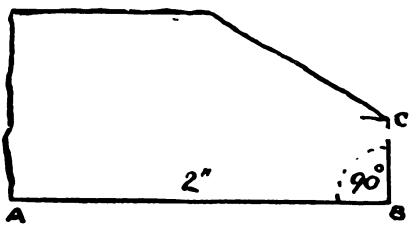


FIG. 13.—RABBET GAUGE. A, B, C = a right angle; B, C = thickness of plank.

fixed in its place, when he can easily see the exact angles required at each section of the rabbet.

Before starting on the rabbet, a gauge must be cut out of a small piece of hard wood about two inches long, an inch wide, and half an inch thick. One edge, A-B, must be carefully planed up, and one end correctly squared to it and marked off to the exact thickness of the planking = B-C. (*See Fig.* 13.) **Making the Rabbet Gauge**

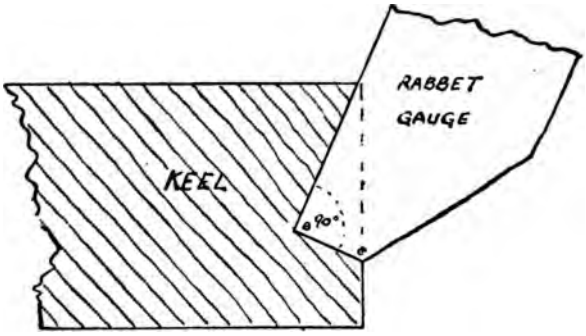
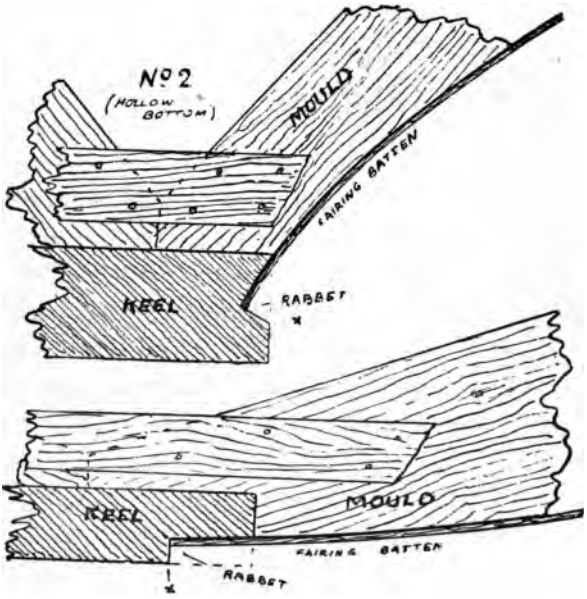


FIG. 14.—B. C = thickness of plank.

Using the Rabbet Gauge

The use of this gauge is to ascertain the proper depth to cut the rabbet at any part, and also to see if the inner angle is correct, the side A-B being placed on the flat of the rabbet (*see Fig.* 14), and the square end, B-C, showing the proper depth and angle.

This gauge should be kept in a convenient pocket, to try



Nº 1 (FLAT OR ROUND BOTTOM)

FIG. 15.

the rabbet continually while it is being cut. In addition to this gauge, a strip of American elm, $\frac{1}{4}$ in. by $\frac{3}{4}$ in. in section, and three or four feet long, is used to bend round each mould to show the angle of the back of the rabbett, with the side of the keel or stem, which must be a continuation of the curve of the mould.

Setting Off the Rabbet

Having prepared the gauge and batten, set off the rabbet line on the keel and stem at each mould, taking the proper position of the lower edge of the rabbet, ×, from the sheer and half breadth plans at each station. This varies very much in the two types of boats now under consideration; in the centre-boarder, No. 1, the rabbet is underneath the keel, while in the keel boat, No. 2, it is on the side. (*See Fig.* 15.)

The only safe way to get it correct, is to make a careful sectional drawing of the keel or stem at each station, and mark the rabbet line ×, on the keel and stem at those points as already stated, drawing a fair line through the spots, and cutting a few inches of the rabbet at each of these places, taking care to follow the curve of the mould, and not to cut quite to the full depth; the accompanying sketch will show how this is done at the moulds 1 and 2. (*See Fig.* 16.)

Cutting the Rabbet

When a section of the rabbet is cut at each of the moulds, take a stiff batten about 12 ft. long and tack it over the moulds, so that the fore end just touches the rabbet-line on the stem at the deck level under the sheer batten; now cut a bit of the rabbet in the same way as before, letting the end of the batten into the stem to the depth of the rabbet, as shown by the rabbet-gauge.

Repeat this about every six inches down the stem and fore-end of the keel till the first mould is reached, taking care that the batten lies flat on the moulds and fits the rabbet; bending the batten over the moulds in the various positions, to get the correct angle for the rabbet at all points from the stem-head to the first mould.

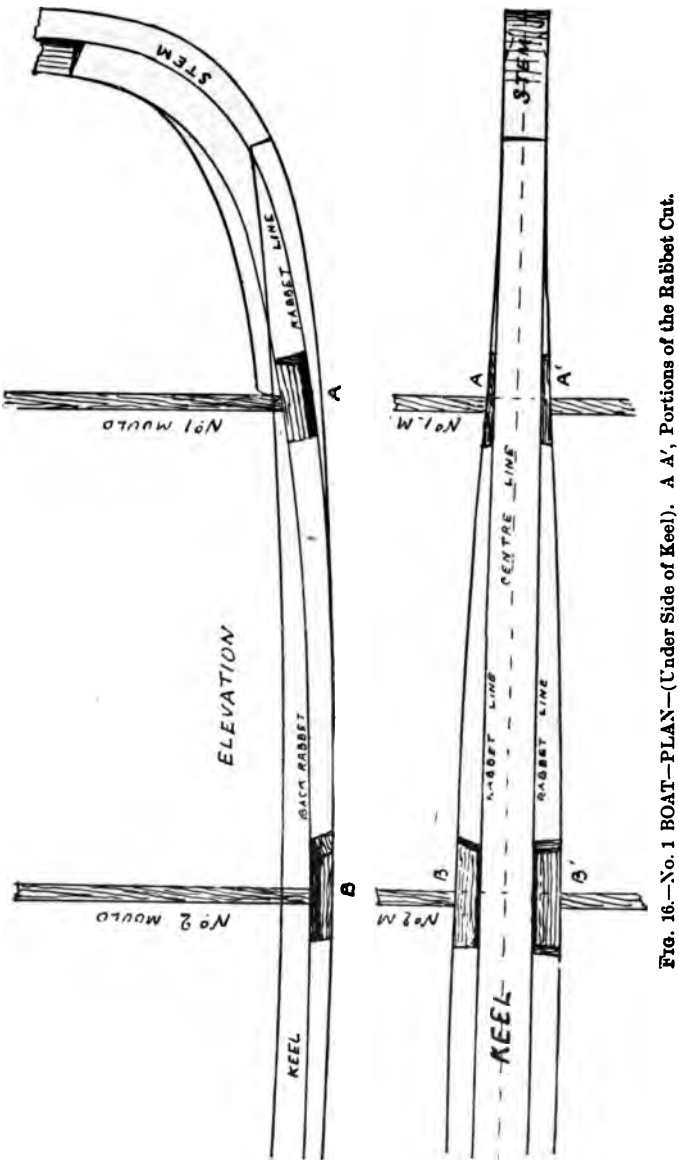


FIG. 16.—No. 1 BOAT—PLAN—(Under Side of Keel). A A', Portions of the Rabbet Cut.

When these sections have been correctly cut at each mould, including the transom of the centre-board boat, and the stern-post and counter-frame of the keel boat, the intermediate por-

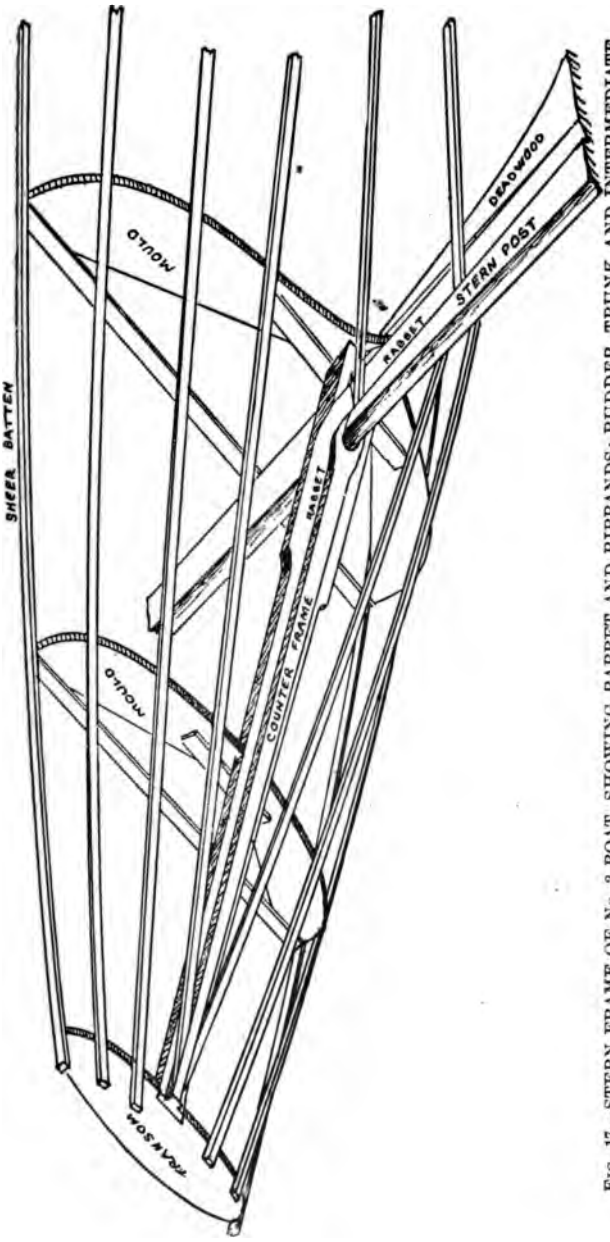


FIG. 17.—STERN FRAME OF No. 2 BOAT, SHOWING RABBET AND RIBBANDS; RUDDER, TRUNK AND INTERMEDIATE MOULDS OMITTED.

tions of the rabbet may be cut and faired up from section to section with the chisel and rabbet plane, testing every part with gauge and batten, and also laying the batten flat along the rabbet, to see that there are no lumps or hollows in it.

Cutting Rabbet on Keel Boat

The most difficult parts to cut are where the rabbet turns from the underside of the keel to the side of the stem in No. 1, and where it runs off the stern-post on to the counter-frame in No. 2. (*See Fig.* 17.) In each of these cases the only way is to cut plenty of small sections as before, continually trying the rabbet gauge and battens, and using the large battens at various angles over the moulds, to fair the rabbet in all directions. As the planking will run past the transom in both boats, all that need be done here is to cut the transom nearly to shape, and fit the joint between plank and transom as each plank goes on.

I have, perhaps, put the cart before the horse in dealing with the rabbet before explaining the method of fairing the moulds by means of ribbands or battens; but it is usual to cut the rabbet roughly to nearly its full depth, and then to fair up the moulds before finishing off the rabbet.

Fairing the Moulds

This fairing (*see Fig.* 18) is done by nailing over the moulds six or eight long ribbands of Oregon pine, or other suitable wood, clear of knots, and at least as long as the boat, with a square section of say $\frac{3}{4}$ in. by $\frac{3}{4}$ in. for the centre-board boat, and 1 in. by 1 in. for the keel boat. They should be fairly evenly spaced on the midship mould, and nailed to it with 2 in. wire nails, and then bent carefully round all the moulds, being fastened into the stem rabbet, and to the edge of the transom. When the curve is sharp, as in the fore-ends of the upper battens, they may be tapered a little, to enable them to bend easily, but the taper must be quite fair and very gradual. (*See Fig.* 19.)

If the battens do not touch all the moulds fairly, they must be made to do so, by either cutting away the moulds that are too full, or by packing up with slips of wood on the slack places.

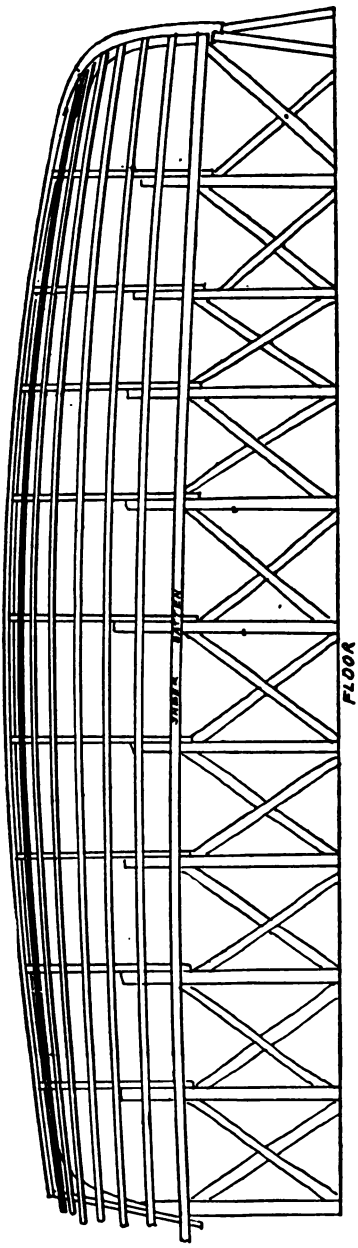


FIG. 18.—FRAME OF No. 1, WITH RIBBANDS IN PLACE READY FOR TIMBERING AND PLANKING.

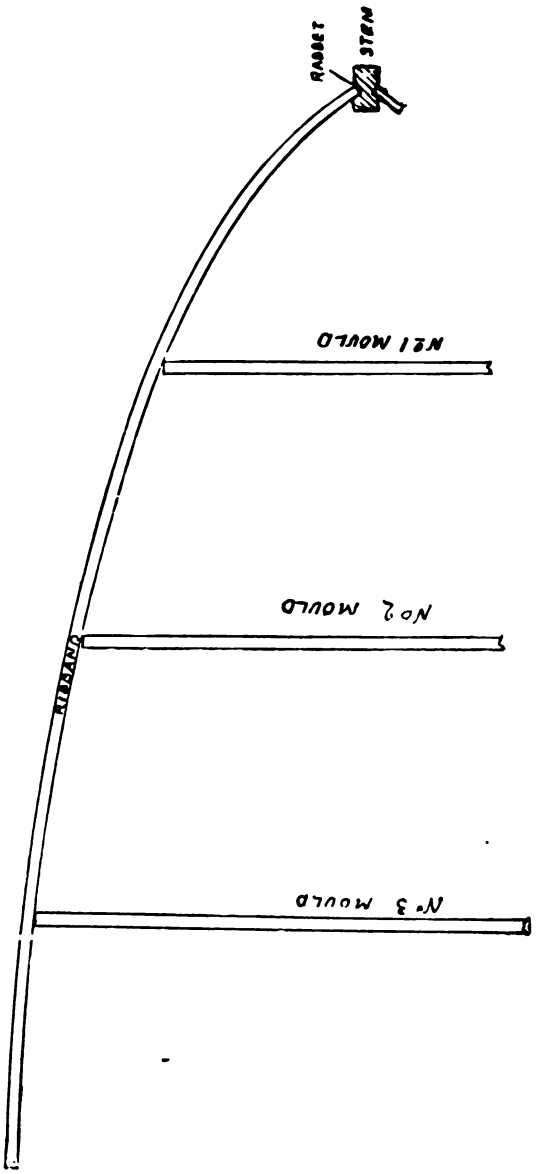


FIG. 19.—METHOD OF FAIRING MOULDS AND STEM RABBET.

This is one of the most difficult parts of the whole work, requiring great patience and judgment, and a correct eye. It is very seldom that all the moulds are absolutely correct, no matter how carefully they have been made, and there are sure to be errors, both in the original design, the full-sized drawing on the floor, and also in making the moulds from the drawing and setting them up; so that it is only by careful fairing with the battens that these errors can be put right.

Fairing the Moulds

A good rule in fairing, when an error is found in a mould, is to go carefully over the measurements at that station, and see if the error is in the mould itself, or in the spacing, or merely through the batten failing to bend fairly. If you cannot find the cause in any of these, then get well away from the boat, first at one end and then at the other, to see if the fault is not at some other mould, which is either too small or too large. Also see if the ribband is pinned, that is to say, fastened at the ends so that it is forced into a greater curve than that required by the moulds; this should not occur, unless a very sudden curve is needed, as in the fore ends of the upper ribbands. Each ribband should be pulled toward the ends of the boat before it is fastened, and should be fastened first to the mid-section and then successively to each of the moulds till the ends are reached.

Do not attempt to start timbering till you have got the moulds, ribbands, and rabbet thoroughly fair, the latter being cut to its full depth and finished; once the timbers are in place it will be difficult to make more than very slight alterations in either moulds or rabbet.

CHAPTER V.

TIMBERING AND PLANKING.

Getting the Material for the Timbers

IN choosing the American elm for the timbers (or ribs), see that it is white in color, close grained, and free from shakes or knots. Get it cut at a sawmill into convenient lengths, say a foot or 18 in. longer than the length of the longest timber, and $\frac{1}{16}$ in. over the moulding and siding given in the specification, to allow for planing up. By having the wood cut in planks and planed up to the exact thickness of the timbers, and then sawn into the proper widths, you can save the labor of planing two sides of each timber; and as this is a very tedious job, it is well worth the extra shillings charged at the mill.

Planing Up the Timbers

Before starting to plane them up, two pairs of cleats or chocks must be screwed to the bench, so that they are the same distance apart in each pair as the width of the finished timber, and an end stop, cut into a V, to hold the end of the timber firmly. All these must be an eighth of an inch lower than the finished timber will be, so as to clear the plane. The first pair of chocks should be about half the length of the longest timber from the end stop, and the second pair a similar distance beyond the first. (*See Fig.* 20.)

The object of these chocks is to hold the timbers firmly on the bench while being planed, and to prevent them doubling up and breaking, as they would do, if simply laid on the bench in the usual manner. Great care should be taken to set the plane carefully, and to keep it sharp, otherwise it will tear the elm badly, and spoil most of it.

The spacing of the timbers must be set off along the keel and sheer batten, according to the specification, taking care that

none of them come just on the mould. At the bow the distance from the stem to No. 1 mould will be found to be much greater

Spacing the Timbers

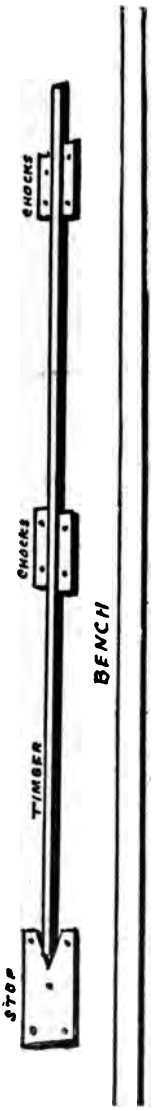


FIG. 20.—METHOD OF HOLDING TIMBERS FOR PLANING.

along the sheer batten than it is on the keel. Therefore, if the spacing were the same on both, there would be a gap on the

sheer batten near the stem, with no timbers. To obviate this, the spacing on the keel is slightly reduced, especially where it runs into the curve of stem, and the spacing on the sheer batten correspondingly increased, so as to set the same number of spaces on both. The result is, that in a boat with a bluff bow the timbers are almost in the form of a fan from the stem scarph to the deck. In boats with an easy curve of stem and deck line, like No. 2, this is not very apparent, but it is there to some extent, and must be allowed for in spacing.

Spacing the Timbers

As the heels of the timbers are to be let into the keel, a small joggle, or notch, is cut in the top of the rabbet for each timber to fit into; and to get these joggles the right width and depth, a simple way is to get two cheap dove-tail saws, about six or seven inches long, set in straight handles, and knock the handle off one. Now get a ¼ in. hole drilled through both ends of each of the blades, and screw them side by side, with a pair of ¼ in. "gutter" bolts, which can be bought at any ironmonger's. Before screwing them up, slip a piece of hard wood, of slightly less thickness than the siding of the timbers, between the two saw blades, and let the bottom of it be parallel to, and at the same distance above the teeth of the saws, as the depth to which the joggle is to be cut. The two bolts will, of course, pass through the wood, and when screwed up firmly, will hold all three together, so that they can be used as a single saw.

Fitting Heels of Frames into Keel

By this means you saw both sides of the joggle at once; and it is impossible to cut it too deep, as the gauge will stop the saws cutting when they get down to the wood.

Before cutting the joggles run a gauge line along the side of the keel of the centre-board boat, as an extra guide to regulate the exact depth to which they should be cut. There is no room for alteration in a keel of this sort, owing to the small amount of back rabbet.

In cutting the joggles, the points of the saws should be used, and the cut started on the angle of the back rabbet and

side of the keel, holding the saw at such an angle that, when it is down to its full depth at the deepest part on the angle, the point of the saw just cuts the inner angle of the rabbet. Remove the wood between the pair of saw cuts with a narrow chisel, so that you have a wedge-shaped notch, as shown in the sketch. (*See Fig.* 21.)

Fitting the Frames into Keel

One end of each of the timbers should be cut to the proper angle to fit these joggles, and it will save a lot of time if they are cut before steaming.

The timbers and keel being prepared according to the foregoing instructions, get up steam in the kiln, or steam chest, and put the timbers in for half-an-hour's steaming. When they are soft, start with the longest, in the middle of the boat, taking

Steaming the Timbers

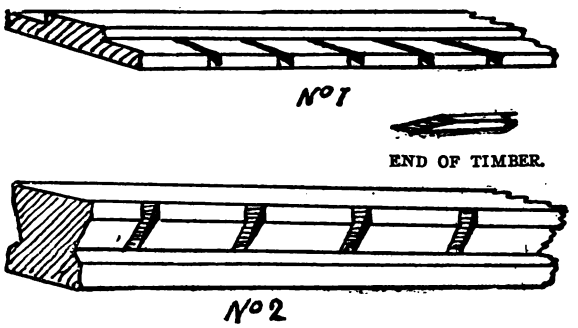


FIG. 21.—METHOD OF FITTING THE TIMBER INTO THE KEEL.

each one quickly from the kiln, and fitting the heel into the joggle in the keel, which, if it is properly cut, should hold it firmly, but a nail must be driven through it to make sure; then pull the timber gently into its place inside the ribbands, working from the keel to the sheer batten, to which the outer end should be nailed, but see that every timber is fairly touching all the battens before nailing the end to the sheer batten.

Bending the Timbers

The boat is now ready for planking; the material for this should be cut to the required thickness, ready for use, and of ample length and width. Before the planking is started, the

widths of all the planks must be set off on the midship mould, stem, and transom; or stern-post and counter-frame, as the case may be. To do this correctly will take a fair amount of patience, to avoid any of the planks running off to a point at the ends, and at the same time to get them narrow enough round the turn of the bilge and quarters to avoid splitting.

Laying Off the Planks

A fairly safe rule is to have the narrowest planks at the bilge, and the widest at the garboard next the keel. The top strake or sheer plank is usually a little wider than the one below it, and they gradually get narrower to the bilge, and then widen out to the garboards. The forward ends of all, except the top strake and garboard, should be about the same width where they meet the stem, but in the counter of No. 2 boat they must be narrowest at the top strake, as the sharpest curve in the transom is just at the deck, and it would be impossible to work a wide plank over such a short turn.

Having set off the widths of the planks on the stem, midship mould and transom in No. 1 boat, and also on the stern-post and counter-frame of No. 2, a batten should be placed over these points, and a fair line marked on all the other moulds and timbers. A very good plan is to start with the garboard, moving each ribband as you come to it if it crosses a seam, but be sure you do not take any of the ribbands entirely off till you are ready to fit the plank, and do not remove the next ribband till the plank is on and nailed to the timbers, or you will have your timbers out of shape. I mention this now in case a ribband should be moved to mark the spacing of the planks. If it is, it must be replaced carefully and fastened, till it has to be removed for the plank. By the way, in No. 2 boat be sure and make a seam come just at the junction of the stern-post with the counter-frame. There is a sharp twist here, and it is very difficult to fit unless the seam comes in the angle between the two.

Most builders dispense with the rabbet on the counter frame in No. 2 type, and let the planks run past the stern-post,

and meet along the centre line of the frame. This saves a good deal of trouble, and also some weight, but for an amateur it is easier to get a tight joint where the rudder passes through the counter-frame, if a rabbet is left, as shown in the previous sketch, because the seam can be caulked if not very well fitted. But where the plank merely lies flat on the frame, and a hole for the rudder is cut through the plank, leaving an exposed joint inside the hole, it requires perfect fitting between plank and frame to prevent leaking, and if a leak should occur there it is very difficult to stop.

Laying Off the Planks

The first plank to be fitted is the garboard strake, or that next the keel. It is generally the most difficult, and should be most carefully fitted, as on this depends much of the strength of the bottom of the boat. To get the exact shape of the edge

Fitting the Garboard

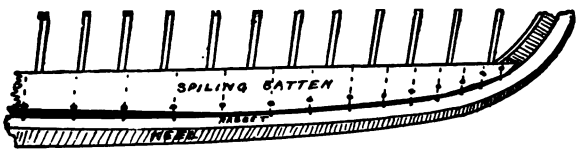


FIG. 22.—METHOD OF FITTING THE PLANKING.

of the plank next the keel, which will have to fit the rabbet for the whole of its length, take two pieces of thin wood, about 5 in. wide, and rather more than half the length of the garboard strake, roughly cut to fit each end of the rabbet, and tacked over the moulds and timbers, so that they overlap each other in the middle. Now take a pair of compasses and set them about an eighth of an inch wider than the widest gap between the edge of the board and the inner edge of the rabbet. With the compasses set to this distance, prick off a series of spots along the boards, say every six inches, till the turn of the stem comes, and there decrease the spacing between the spots (or "spilings") to every three inches. Always keep one leg of the compasses against the inner edge of the rabbet, and be careful to mark the spilings at right angles to the board, or "spiling batten" as it is called, and *not* at right angles to the rabbet line. The ac-

companying sketch shows how this should be done. (*See Fig. 22.*)

If the spilings were taken at right angles to the rabbet round a curve, they would never give the true shape of the curve, but would give a smaller curve of similar shape and sharper turn, like two concentric circles.

When the spilings are all pricked off on the boards, take them off the boat and cut the edge to the spiling spots and try them up in place again, fitting the edge with a small plane till you have a good joint all along the rabbet. Then, with the spiling battens fitted carefully into the rabbet, nail them together where they overlap each other, so that they are quite rigid like a single plank. They can now be taken off the boat and laid on a piece of the planking, a pencil line being drawn round the fitted edge. Mark off the width of the plank in the centre and at each end, and sweep in a fair line with a batten through these spots, but cut it an eighth of an inch outside both lines.

Marking Out the Garboard

The plank should be tried up in its place and fitted to the rabbet in the same manner as the spiling batten; but greater care must be used, not only to ensure a perfect fit, but also to avoid cutting away more of the edge of the plank than is absolutely required. The final fitting is done by chalking the inside of the rabbet, and cramping and shoring the plank carefully to its place, tapping it close with a hammer along the outer edge. When the shores are removed, it will be found to be marked by the chalk where it has touched it, and these places should be planed off till it shows the chalk mark all along.

Final Fitting of Garboard

The outer edge should be shot fair and to the correct width, with a jack plane, and both sides of the plank planed up.

It is now ready for fastening in its place, and the rabbet must have a coat of either red and white lead and varnish, or some thick varnish out of an old can. The latter is best for a varnished boat, but the other is more durable.

Before fastening the plank in place, it should be tried up in place, on the other side of the boat, and if it is a fairly good fit, as it should be, it can be laid on another board and the opposite plank marked off from it.

Cramp and shore the plank into its place as before, driving it tight into the rabbet, and start nailing at the fore end, carefully boring to the full depth of the nails with a boat-builder's piercer a little smaller than the nails. **Fastening the Garboard**

Nail the inner edge first, taking care that the plank does not get away from the rabbet. The nails should be spaced apart about five times the thickness of the plank along the keel, and about three times the thickness up the stem.

After nailing the plank along the rabbet, the outer edge must be cramped and shored close to the timbers, and nailed to each with copper nails $\frac{1}{4}$ in. longer than the total thickness of plank and timber. An intermediate nail should also be placed in the middle of the plank at each timber, but care must be taken that these are not all in the same line of the grain of the plank or it may split. In very wide, thin planks the intermediate nails are increased in number; a good rule being a nail for every four inches in width in $\frac{1}{2}$ in. planking, or spaced eight times the thickness.

For the rest of the planking it will not be necessary to fit the spiling batten itself to the edge of the last plank, but by using a spiling batten as long as the boat, and about 3 in. by $\frac{3}{8}$ in. with straight edges, the spilings for each plank in turn can be set off on the batten, and then erased when done with. **Fitting the Planks**

In using this straight spiling batten, it must be laid quite flat on the timbers, without any twist edgewise; and just touching the edge of the last plank, from which the spilings are to be taken. It will be found that in some places it is several inches away from the edge of the plank; so that the spilings, if taken with compasses as before, would not all come on the batten. To get over this difficulty, instead of using the com-

passes, the distance from the edge of the plank to the batten is taken at right angles to the batten, every foot or so, and written on the batten alongside the line on which it is taken. Where the distance is not to an exact sixteenth of an inch, it is usual to write it down thus:—$3\frac{7}{16}^{\circ}$, meaning "full," or just over the $\frac{7}{16}$, while if it is under the nearest sixteenth, it would be written $3\frac{7}{16}$—or "bare." Another sign is $\underline{\downarrow}$ or "hard off," used where the edge is touching.

Getting Good Seams

The great secret of getting a tight boat is well-fitted seams, and these can only be got by careful spiling, and trying up the planks several times before fastening them, chalking the edge of the last plank each time, and planing off the chalk marks on the new plank, till the chalk marks the edge all along, as explained previously.

If the seam is to be caulked, it must be left open on the outside and tight on the inside, so as to hold the caulking. For $\frac{1}{2}$ in. planking, a sixteenth of an inch is wide enough for the outside of the seam, though a first-class builder would not caulk such thin planking at all, but would fit the two edges perfectly watertight without any stopping, only varnishing each seam as it is fitted.

This is rather beyond an amateur's powers, and is only done by one or two of the very best builders, so it will be best to caulk all seams.

From the foregoing description it will be seen how important it is to make good seams, and it is really a matter of care and patience more than great skill; though even after the first difficulties are overcome, several planks are sure to be spoiled; but that is of no consequence, as each failure teaches something, and the spoiled plank will always come in for some other part.

So far, we have been considering the planking as if each plank was in one piece, but this will seldom be the case with all the planks, even in a long, easy boat, while in a short, hard bilged boat like a dingy, there would be very few planks with-

out a scarph, as not only would the curve, or "sny," of the plank be too great for the widths of the boards, but even if it could be cut out in one piece, the grain would run so short across the ends that the plank would be very weak and would be sure to split in nailing. The waste of wood would also be very great, and it would be difficult to take an accurate spiling for such an extreme curve.

Scarphing the Planks

For these reasons, it is usual to scarph all planks where the curve, or "sny," exceeds the width of the widest part of the plank, in the following manner: The after half of the plank is fitted in place, as previously described, but before finally nailing it, the scarph is cut on the end. The best form of scarph is that known as a "butt scarph," and in this, the after end of the forward half of the plank overlaps the fore end of the after half for about 2 inches. The two ends are carefully tapered off so as to fit each other; the after end of the forward half plank being let into the other, about $\frac{1}{8}$ inch or more, according to the thickness of the planking, and the fore end of the after half plank being tapered to a feather edge; this feather edge should come on a timber, so that when the scarph is nailed, the nails in the fore end of the scarph will go through the timber; those on the after end or "butt" of the scarph being clenched inside on the plank.

It is most important that all scarphs should be very carefully fitted, as a leaky scarph is difficult to put right. All such joints should be made with a small iron plane, and when they are a good fit they must be well painted with thick red and white lead, or some similar preparation. The nails should be finer than those used in the rest of the planking, and great care used not to split the end of the plank, as the row of scarph nails should be only half an inch from the edge, and about an inch apart or less.

Where there is a sharp turn in the timbers, as at the bilge and on the quarters, the planks for these parts should be cut

from boards a little thicker than the rest, to allow the centre of the plank to be hollowed on the inside to fit the curve of the section, and it will also be rounded on the outside to correspond.

Hollowing the Planks

The hollowing is done with a round soled plane, which is easily made from a small wooden smoothing plane, by rounding the face and grinding the iron into a curve of about $\frac{1}{8}$ in. to 2 in. of width of iron.

As soon as the planking is finished, before clenching off the nails, the moulds will have to be removed. To do this the centre-board boat will have to be turned over, keel down, but the other can remain on the stocks.

Turning the Boat Over

Before turning the boat over all the stays of the moulds and on the stem and stern of the boat must be cut adrift from their fastenings, and when that is done, she can be lifted clear of the floor by about four men, and turned over on two trestles. Four or five light strips of wood, called "cross spauls," with cleats on their ends, should be fitted over the edges of the top strake between the moulds, to hold the boat in to her beam, as if this is not done she will fly out several inches at each side directly the moulds are removed. This must be done on both boats.

Removing the Moulds

The moulds can now be removed; the easiest way is to cut them across in one or two places with a saw, but if they are to be retained for future use it will be a longer job to get them out whole, and great care must be taken not to injure the planking and timbers.

NOTE.---A small piece of hard wood, 3 or 4 in. long, by $1\frac{1}{2}$ in. wide, and 1 in. thick, with a stout nail or screw in the centre, is very useful to fasten on the side of the stem, to hold the ends of the plank when trying up in place, and is shifted as required.

CHAPTER VI.

Floors, Shelf, and Deck Beams.

THE planking being finished, and all the through fastenings clenched properly over roves or burrs, the positions of the floor timbers should be set off from the construction drawing. The stations are usually marked F-F-F on the drawing, or else the floors are shown on the drawing in their places.

A thin wooden template is made to fit the inside of the skin and keel, etc., at each station, and from it the floor is made either in steel or a natural oak crook. The latter is the simplest for the centre-board boat, and the bow and stern floors in the keel boat; but the hollow sections amidships on the latter will require steel floors, as suitable crooks could not be obtained easily, and would be very difficult to fasten. These steel floors can be made by any smith from the template, if it shows the bevel required. This is usually done by nailing small blocks of wood on the sides of the template at about four places, from the angle of the keel and garboard to the end of the arms. These blocks must be the exact width of the finished forging, and must show the angle or bevel of the planking with the template at each point.

Fitting the Floors

When ordering the iron work, always give a correct template, as well as a full-sized drawing of each piece, and if possible let the smith have a look at the place where it is to go.

All ironwork must be fitted in place and drilled, and the holes countersunk before being galvanized.

The oak floors are cut roughly to shape from the template, giving the edges the proper bevel when sawing out the crook.

They should then be tried in place, and if a fairly good fit, the inside of the skin and keel, at the floor of the station, should be chalked, and the floor fitted exactly to its place in the manner described in the previous chapter for fitting the planks; and when it is fitted, the sharp angle at the junction of the planking and keel should be partly cut away, to leave a water course or "limber hole." This is constantly omitted, even by good builders, but is most essential if the boat is to be kept clean and sound, for if there is no proper water course, the boat cannot be pumped out dry, and water will always lie in the angles of the floors. The limbers must not be cut too large, or the joggle over the keel will be cut away, and much of the strength lost; a fair proportion for most boats would be two-thirds the height from the inside of the plank to the top of the keel at the joggle, and about twice that amount in width.

Cutting Limber Holes

Even with these limber holes in the floors, a small quantity of water will remain in the angles of the timbers, but that cannot be helped.

A good rule for the sizes of wood floors is to make the siding equal two or two and a half times the thickness of the planking, and the moulded depth on the top of the keel two or two and a half times the siding, thus for $\frac{1}{2}$ in. planking, the floor at the top of the keel should be 1 in. to $1\frac{1}{2}$ in. by 2 or $2\frac{1}{2}$ in., according to the strength required at the different stations, the stoutest floors being at the mast step and amidships, and the lightest at the ends. *All floors should run up to the turn of the bilges amidships,* and the arms should taper fairly from the keel to the end, which should be square in section, so that if the floor is 1 in. sided, it would be 1 in. by 1 in., at the ends of the arms. In No. 1 boat, the floors form the bearers for the flooring or platform, and are of greater moulded depths than these proportions. Steel floors are usually of a flat section in small boats such as we are now dealing with, and should be about half the thickness of the planking at the keel, with a

Size of Floors

width of about four times the thickness. For ½ in. planking, they would be 1 in. by ¼ in. at keel, and would taper to the ends of the arms to half those dimensions.

Paint well under each floor before fastening the same in place.

The shelf, which is also known as the inwale in small boats, varies considerably in its proportions to the rest of the scantlings, according to the class of the boat. For instance, in some very light boats of barely $\frac{3}{16}$ in. planking, with bent timbers ¼ in. by ¼ in., spaced 2 in. centre to centre, the inwales were 1½ in. by ⅞ in. tapered fore and aft to ⅝ in. by ¾ in., the boat being about 25 ft. o.a. and 5 ft. 6 in. beam. In an ordinary strongly built boat of the same dimensions, but with ½ in. planking and ⅝ in. by ¾ in. timbers, spaced 5 in. centre to centre, the shelf would be about 2 in. or 2½ in. by 1¼ in., tapered to 2 in. or 1½ by 1 in. at the ends. That is to say, that though the planking is nearly three times as thick, and the sectional area of the timbers more than seven times as great, the shelf is little more than double the sectional area of that in the light boat. The shelf of the heavier boat, however, would be fastened inside the timbers, and if it is placed below the level of the deck, it would not be cut away more than ½ in. for the dovetails of the deck beams, the timbers not being let into it at all, while the inwale of the light boat would have all the timber heads let in flush, and the beams let in to their full depth, but only half way through the thickness of the inwale at the top, the dovetail being tapered to nothing at the bottom of the beam. By this method the inwale touches the deck and the planking, both of which are fastened directly to it. This is necessary with such light material, to tie the skin and deck edge together, as they are both too thin to fasten to each other in the usual way by nailing or screwing the deck to the top strake.

The Shelf, or Inwale

The method adopted in No. 1 design is a compromise between these two, the shelf being flus. with the deck, with the

beams let into it for half their depth, and half way through it, the timbers not being let into it.

The term "shelf" is usually applied to the heavier class of work only, but I shall use it here to denote the form of construction in which the timbers are *not* let in, using the word "inwale" in place of shelf when the other method is required.

Material for Shelf

It is most important that the shelf should be quite free from knots or short grain, and for that reason Oregon pine is one of the most suitable woods; but for the inwale of a very lightly built boat American elm is better, as it will not fly so easily when cut across the grain to let in the timbers and beams. The only objection to American elm for all work of this sort is its weight and expense; but if Oregon pine were used in cases where the timbers are let in, it would probably split in several places, especially between the dovetails of the deck beams. A light, tough mahogany is not a bad substitute for both the former woods in either class of work, but it is as expensive as the American elm, while not equal to it in toughness, and it is considerably heavier than the Oregon pine, though more durable, and less likely to split.

Steaming the Shelf

As soon as the pair of shelves are cut out to the correct section and taper, they will require steaming at the fore-ends to the curve of the boat. To save time they are usually cut out, planed up and steamed before the floor frames are fitted, being bent round the top strake and cramped or lightly nailed in place to set to their proper shape by the time they are wanted. Occasionally the after ends will have to be steamed as well, in which case they must be done separately, one end being steamed and left to set all night before taking it off the boat to steam the other end; unless the steam-box is long enough to take the whole length, which is hardly likely.

Before putting in the shelf, the edges of the top strake must be planed down to the correct sheer line, and this takes a lot of careful work and a well-trained eye, or there will be

"lumps" or "straights" in the sheer. Use a jack plane, set fairly coarse at first, and get well away to look at the sheer occasionally, as you plane the edge. Be sure you get the sheer right now, as you cannot alter it much afterward. Don't touch the top of the transom till the deck beams are faired up.

Fairing the Sheer

When fastening the shelves in place, fit the fore ends against the inside of the stem, and to each other, so that when the breast hook is fitted afterward, the whole fore end of the boat will be a solid block, composed of stem, shelves, breast-hook and planking, with the space between shelf and plank carefully filled up with the same material as the planking.

Get the shelf in place and hold it firmly with three or four cramps, driving it tight against the stem, and for No. 2 boat, keep the top half an inch above the level of the under sides of the deck beams. This level can be marked all round the inside of the boat before the shelf is fitted. For example, if the beams are 2 in. moulded at the ends, the level of the top of the shelf would be $1\frac{1}{2}$ in. below the sheer line. If the beams are to be flush with the top of the shelf, as in No. 1, keep the latter level with the top strake.

Putting the Shelf in Place

Start fastening from forward, putting a through fastening through plank, timber and shelf, at every other timber, each fastening being alternately in the top and bottom edges of the shelf.

When within a few feet of the after end of the shelf, cut it to fit tightly against the transom in the same manner as the fore end fits against the stem. It will be tied to the transom with a quarter knee. There is often a lot of twist in the shelf here, especially in long counters like that of No. 2 design, and care must be used to get it in place, nailing it at every timber if required, and thinning it at the ends to make it bend easily.

The bilge stringers are the next to go in, and owing to their length being equal to that of the boat, they cannot well

be fitted after the deck beams are in place. These very essential portions of the frame are somewhat similar in section to the shelf; and like it, are worked from end to end of the boat inside the timbers, to give longitudinal strength. Unlike the shelf, they are often placed on edge, and are wider at the base, where they touch the timbers, than they are at the top. A good proportion for the section would be a moulded depth amidship, equal to four or five times the thickness of the plank, with a width at the base equal to one-third of the depth, and at the top edge, equal to one-quarter the depth. The ends would taper in the same manner as with the shelf.

Bilge Stringers

The stringers should be placed right in the turn of the bilge, just over the ends of the floors, which may be cut away to allow the stringer to lie flat on the timbers. Like the shelf, they should be thoroughly fastened at every other timber, and at each floor.

Where a stringer on edge would interfere too much with the internal room, a slightly stouter one may be worked on the flat, but it will not be so strong for its size.

Before cutting out any of the deck beams, a mould must be made for the longest beam in the boat, and from this template, all the beams can be drawn out on the boards from which they are to be cut, placing one inside the hollow of the next, so as to waste as little wood as possible, and taking care that the wood is sound and clear grained. Where headroom is not an object, it is best to make the beams thin and deep in section with the ends of less depth than the middle, the moulding amidships being about four times the siding, the latter being the same as the thickness of the deck. If, however, every bit of headroom is wanted, they may be square in section, but should, in that case, be of greater sectional area to make up the strength required.

Cutting Out the Deck Beams

The ends of the beams are fitted carefully to the inside of the planking at the stations shown on the construction plan,

when they rest on the shelf, and, in this case, they are checked ½ in. over the shelf with a long nail driven down through the beam into the shelf. In the other method, which is adopted in No. 1, the ends are cut off at the shelf and dovetailed into it. When all the main beams are in place, the fore and aft beams or carlines are fitted, the ends being dovetailed for half their depth into the two end beams, but the dovetail must not be cut more than half way across the beams. The half beams from shelf to carline are fitted just the same as the rest of the beams, all joints being dovetailed.

Fitting the Beams

The beams and carlines should be cut out about ¼ in. deeper than the specified molded depth, and when they are in their places they should stand ¼ in. above the deck level. This is to allow enough wood to "fair" them off, which is done by laying a long batten on them from end to end of the boat, and planing off all lumps until the batten touches every beam and also the top strake at the sheer line if it is moved to either side. When the batten is first laid over the beams and transom it looks a hopeless job to get them fair, but if the high beams are chalked and then some of the surplus planed off, and the batten again tried until they are fair, there should be no great difficulty, but it takes a lot of time and patience.

Fairing the Beams

Having fixed and faired the beams, fit the knees and the shaped pieces from carlines to the beams at the end of the cockpit, and for all these, thin wooden templates must be made and the knees, etc., cut out by them from the oak crooks, as in the case of the stern.

Fitting Knees

The breast hook is the most important knee in the boat, and should be at least equal in thickness to the shelf. The moulded depth will, to some extent, depend on the grain and quality of the oak. In the case of boats where the shelf is below the sheer level, the top of the breast hook will also be below the deck level, and will have a packing piece on it up to the level of the end of the deck.

The positions and shapes of the knees are shown on the construction plan, and all these will be about the same thickness as the planking, or a trifle stouter; they should all have at least three through fastenings in each arm.

CHAPTER VII.

Centre Case and Rudder Trunk.

THE method of fitting the rudder trunk of the 24 l.r. cruiser has already been described, and it should be done before the frame is set up.

The centre case of No. 1 design may also be partly fitted at the same stage, that is to say, the keel can be rabbeted and the slot cut. Both case and trunk, however, must be finished and fixed after the boat is planked, or else the joint between their lower edges and the keel may go out of shape, and leak afterward.

Taking the centre case first, we will go through the whole process from the commencement, and start by cutting the rabbet on each side of the slot in the keel as described in Chapter III.

Fitting the Centre Case

The width of this rabbet should be one-third of the thickness of the sides of the centre case or rudder case, and should be on the outer edge. Its depth should be about half its width, and it must be exactly parallel with the slot in the keel, and of a uniform width and depth throughout. It must be carefully set out in pencil on the keel before starting to cut it out, and should be roughed out with a narrow chisel to nearly its full depth, and finally finished at the same time as the lower edge of the case, chalking and fitting them to each other till a good joint is obtained. The insides of the two side pieces should be painted with two coats of good red and white lead paint with plenty of oil in it before fixing in place.

Cutting Rabbet

While they are drying, the end stanchions can be cut out and fixed into the keel, and when the sides of the case are

ready the rabbet in the keel must be filled with white lead and varnish as thick as cream, the stanchions being covered with the same mixture; the sides can then be driven home into the keel, and kept in place by cramps on the ends, holding them to the stanchions.

Fitting the Stanchions

The stanchions should be $\frac{1}{4}$ in. thicker than the width of the slot, having a shoulder $\frac{1}{8}$ in. on each side to prevent them going too far through the slot when driven in their places.

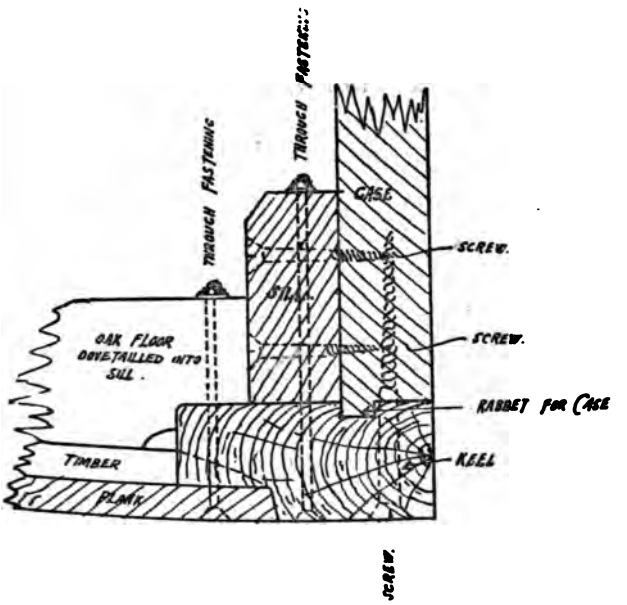


Fig. 23.

The sides of the case are rabbeted $\frac{1}{8}$ in. at each end, to take the extra thickness of the stanchions, so that all joints are rabbeted, and bedded in white lead and varnish.

Fastening the Centre Case

Screw up through the keel into the sides with long brass screws, as shown (*see Fig.* 23), and screw the sides into the stanchions. Fit the sills over the ends of the oak floors, which have previously been cut off to the side of the case. They should be dovetailed into the sills.

These sills are merely flat strips of mahogany, or other suitable wood, extending the whole length of the case and fitted to the keel and side of the case. In some lightly built boats they are carried beyond the ends of the centre case, extending for some distance fore and aft, forming a stiffening web for the keel along that part where most of the strain comes. The fore ends would go forward of the mast step in this case, and the sills would be well fastened all along the keel.

Fastening the Centre Case

They must be bedded in white lead and varnish, closely screwed to the case, and fastened through the keel with stout

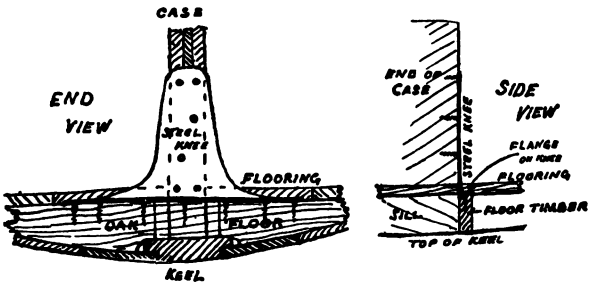


FIG. 24.—SKETCH OF CASE KNEE.

copper nails. A pair of knees should be fitted over the sills on the sides of the case at the plate bolt, and another pair at each end of the case, the latter being of sheet metal. (*See Fig.* 24.) The rudder case is fitted in the same manner, but the slot is wider at the fore-end to take the stem of the rudder. No knees are required on the rudder case.

The knees at the sides of the centre case, mentioned in the last paragraph, should be made of wrought iron, or steel, galvanized, and they should either be fitted on one of the regular floor timbers, or else a short extra timber must be put in for them to rest on, as they should never be placed directly on the inside of the planking. They should be 1 in. wide and $\frac{3}{8}$ in. thick at the angle of the case and keel, the

Knees on Centre Case

arms being at least a foot long and tapered to $\frac{3}{4}$ in. by $\frac{3}{16}$ in. at each end. The upper arm, against the case and sill, must be screwed to them with stout brass screws as long as possible; but of course they must not go quite through the case. The lower arm must be through fastened with stout copper nails, through planking and floor timbers. Extra knees may be used at each floor timber all along the case if the boat has to knock about on the ground much, but they should be a bit lighter than the above. The knee which is fitted at the centre-plate bolt should be swelled out sufficiently to let the bolt go through it, and before it is fastened, a piece of leather should be placed between it and the case to make the bolt-hole watertight.

nees on entre Case

The rudder trunk, or rather case, of the centre-board boat, must be fitted watertight to the deck, and to insure this, it should be left about $\frac{1}{4}$ in. above the level of the deck, till after the beams are in place, when it can be faired up with them. It must have a fillet, or ledge, along the top on each side to screw the deck into.

When the rudder is in place in the case, the head rests on a circular gun metal plate, which is fixed on the deck at the fore end of the case, being raised about an inch above the level of the deck on a small block of mahogany or teak, turned to fit the plate, the after part of both plate and wood block being cut away to allow the blade of the rudder to pass if it is desired to remove the rudder entirely, but it is both stronger and simpler if the rudder only pulls up into the case, and is held up by a pin through the rudder stem; in this case the top of the case is closed, and does not show on the deck. A stout metal washer should be placed between the under side of the tiller and the deck plate, to reduce the friction, and a metal plate should be let into the keel at the bottom of the fore end of the case, to form a lower bearing for the rudder, but it must be cut away aft, to allow the rudder to lift.

udder se

If it is not necessary to lift the rudder at all, owing to

the boat being kept afloat, it will save a lot of work to use a piece of soft, solid drawn, brass tube for the rudder trunk. This tube must be $\frac{1}{8}$ in. larger inside than the stem of the rudder, and should have a gas thread on each end, the lower end being screwed tightly into the keel and filed off flush outside, while the upper end projects 1 in. above the deck with hard wood block and gun metal plate, referred to above, screwed tightly on to the top of the tube, and then to the deck. This is the simplest and best form of trunk, and never leaks, but, of course, the rudder can only be removed from below.

Tube for Rudder Trunk

CHAPTER VIII.

Laying the Deck, Coamings, &c.

DO not attempt to start on the deck until all the inside work, such as knees, floors, centre, and rudder cases, etc., is finished. The more inside work that is done before the boat is decked, the better, as afterward there is not only less light under the deck, but it is very cramped and awkward to work in such a small space.

Put in any bulkheads that may be required, and line the cabin, etc., but the details of this will be found in a subsequent chapter. The seats and flooring of the centre-board boat may be done either before or after decking. The deck of No. 1 boat will be made of best quality $\frac{5}{8}$ in. match boarding, and in laying it, start from a centre line, working to the sides, and letting the ends of the boards overlap the deck edge, and also the inside line of the cockpit. These ends can be trimmed off afterward. See that all the tongues and grooves in the match-boarding are unbroken, and well painted before they are fastened in place; and of course keep the beads on the under side, which must have two coats of paint before it is fixed.

aying
he Deck

Drive each joint up tight, with shores from the shelf or planking, and nail to the beams on both edges and in the middle of the plank.

When all the deck is on, the edges must be trimmed off with a draw knife or saw, and planed to fit the planking, being screwed to it about every three inches all around the edge, also round the inside of the cockpit. Now punch the nails about $\frac{1}{8}$ in. below the surface, the screwheads being counter-

sunk to a similar distance, plane the whole deck smooth and fair, finally going over it with coarse glass paper to take out the plane marks. Dust it carefully, and give it a good coat of red and white lead priming. When this is dry, stop all nail and screw holes, and the joint between deck and planking, taking care there are no "holidays" or forgotten places. A coat of white paint should go over the stopping and be well rubbed down when dry, leaving the deck ready for canvasing.

Smoothing the Deck

The material generally used to cover the deck is either thin linoleum, or stout unbleached cotton sheeting, which can be obtained wide enough to cover the whole deck in one piece.

The deck must be covered as thickly as possible with a coat of white lead and varnish as thick as cream, and while it is wet lay on the linoleum; or stretch the centre of the cotton along the centre line of the deck, as tight as two or three men can pull it, tacking it at the ends of the boat and cockpit with ½ in. copper tacks.

Putting On th Cloth Deck

Now get several other men or strong boys to help you, and, starting at the stern, stretch both sides at once across the boat, tacking it around the edge of the deck every three inches as you go along, and always rubbing it out from the centre line to the sides to get rid of any air bubbles, as if you were mounting a photograph on card. Be careful to stretch it equally all over, and to work out any creases, and when it is stretched and nailed tightly all over the deck, nail round the edge of the cockpit, and cut out the hole, turning the edges down into the cockpit and tacking them like the outer edges if cotton is used.

The white lead and varnish will soak through the cotton, when this is used, and another coat of the same paint over the whole deck will join the coat underneath, and become one solid piece with the wood deck when dry; but linoleum will not require any further painting after it is nailed on to the painted deck.

Painting the Cloth Deck

If a deck is covered in this way, it should not show any wrinkles and bubbles afterwards, but it all depends on the stretching, getting dry wood for the deck, and using plenty of paint.

The deck of No. 2 design is not covered with canvas, but is laid in narrow tapered planks of best yellow pine or kauri pine, with the centre or king plank, and the outside plank or covering board of teak. All nails are hidden, and the seams are caulked, being payed, or filled, with marine glue.

This method of decking is the same as that in use on all large vessels, and looks far better than the canvas or linoleum covered deck of the centre-board boat, but it entails a great deal of labor, and is much more costly, besides being difficult to make watertight. The canvas-covered deck can be used equally well in the 24 l.r. cruiser, if desired, but as the laid deck is the usual method in first-class work for boats of this size, a description of it will be useful.

ring Deck No. 2 Design

Set out the width of the covering board and king plank on the beams, and treat the deck as if there were no openings for the cockpit and cabin top, putting in a rough temporary beam across the opening to set out the widths on. About 4 inches will be a suitable width for the covering board amidship, and it should taper to 3 inches fore and aft, with the shaped piece round the stern, about 6 inches wide in the centre. The covering board should project about its own thickness (say $\frac{3}{4}$ inch), outside the planking, all around the boat. It must be screwed into each deck beam and to the top of the planking, with stout $1\frac{3}{4}$ in. brass screws, which should be countersunk $\frac{3}{8}$ in. below the surface; the holes being plugged with small pieces of teak to match the rest of the covering board, any joints in it being butt-scarphed as in the planking; but screwed and plugged instead of being nailed.

The king plank should be 2 in. wider amidships than the diameter of the mast, and it should taper to 4 in. wide at

each end. It cannot, however, be fitted till all the rest of the deck is on, as it is the closing plank, and must be driven tightly into its place.

When the covering board is fixed, divide the space between it and the king plank at the widest part of the boat into a number of equal parts, as near 1¾ in. each as possible. Then divide into the same number of equal parts two other beams, one-half way between the midship beam and the bow, and the other half way between it and the stern. Bend a stiff batten through each set of marks and pencil the line on all the beams from end to end of the boat. In this way the exact width of each deck plank will be shown on every beam, and also the ending of all the planks in the covering board.

Spacing the Deck Planks

Get enough long narrow planks for the deck, cut out to the greatest width required amidships, and have a ⅛ in. bead worked on one of the lower edges, both sides being planed up. Take one of these planks and mark off on it the positions of the deck beams. Set off the correct widths for the first plank next to the covering board at each beam, and cut the edge which has no bead to these marks, planing it with a slight bevel on the edge, so as to leave a caulking seam on the top. Bend the plank into its place and fit it in the same manner as the outside planking, described in a previous chapter, the edge with the bead being nearest to the centre of the boat. Now bore horizontally through it from edge to edge, till the bit enters the edge of the covering board, taking care the bit does not run up or down, but is kept exactly parallel to the surface of the plank. These holes should be placed, one between each deck beam, and a long copper nail driven through each, so as to go at least an inch into the covering board. The plank is held flat on the beams by several cramps while being nailed, or else the edges may not keep in place.

Fastening the Deck Planks

When all the horizontal nails are in, drive a skew nail diagonally through the inner edge of the plank into each beam,

punching the head well in, and taking care not to bruise the top edge. These two sets of nails hold both edges of the plank firmly, and neither of them shows on the surface. The sketch explains this method of nailing, and shows a seam with caulking and marine glue. (*See Fig.* 25.)

The rest of the deck planks must be cut out to shape and nailed in the same way, and the bead on the under side of each must always be kept on the inner side of the plank.

Fitting the Butts

If, owing to long planks being unattainable, a butt has to be made, it should be screwed up from below, taking care

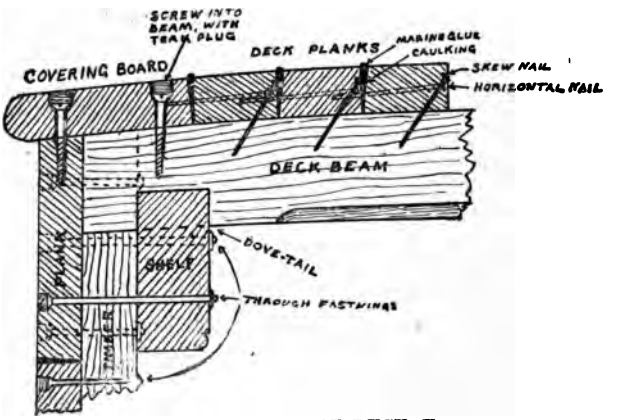


FIG. 25.—SECTION OF DECK, ETC.

that the points of the screws do not come through, and that it comes partly on a beam.

Fitting the King Plank

After the deck planks are fixed, the king plank must be exactly fitted to the gap between the two sets of planks, and driven tightly into its place and screwed down to the beams like the covering board. There should be no difficulty in getting it tight, for where the cabin-top and cockpit come the planks will all be cut off a few inches inside the opening as they are laid, and the king plank will be put in, in two tapered pieces, one at each end of the boat.

Trim off all plank ends, etc., to the sides of the openings for the cabin-top and the various hatches.

To get the shape of the coamings, or sides of the cabin-top, in either boat, bend a thin piece of common wood about 8 in. or 9 in. wide into the place where they are to go, shoring it well into its proper position as to curve and flare (or angle with the deck), then run a pencil round the deck and mark its level on the template and cut the lower edge parallel to the deck level, but low enough down to reach to under side of the carlines and beams when in place. Lay it on a suitable piece of wood and run a pencil round the lower edge, and set off the heights above the deck level to enable the top edge to be

Fitting the Coamings

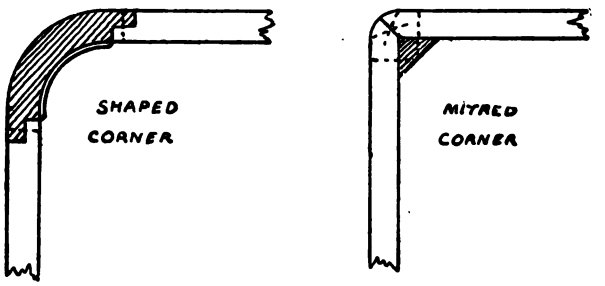


FIG. 26.—JOINTS AT ENDS OF COAMINGS.

roughly cut about 1 in. too high. This will be planed down to the correct shape when fixed.

The coamings of the No. 1 boat will be put in in two halves, meeting in a point forward, and they will require steaming at the fore ends before fitting to their places. A $\frac{1}{4}$ in. bead should be worked on the lower inside edge before steaming, and when finally fitted in place, they must be screwed every four or five inches with stout brass screws.

The sides of the cabin-top in No. 2 boat will be in three pieces, the front semi-circular piece being steamed and bent round in the same way as the other boat's coamings, except that, as it is $\frac{3}{4}$ in. teak, and at least a foot wide, it will require

several hands to get it in place, and very careful handling, with plenty of shores and cramps to keep it in place while it cools.

The two side pieces, being nearly straight, can be put in cold, and must be scarphed to the ends of the front piece.

The after ends of both boats' coamings will be mitred to the ends of the thwartship coaming and a small chock of the same wood screwed inside. (*See Fig.* 26.) Small coamings must also be fitted to all hatchways in the deck.

Making Cabin-top on No. 2 Design

The cabin-top on No. 2 design looks a formidable undertaking for an amateur, but it is not nearly so bad as it looks. A mould should be made at the after end, similar to those used in building the boat, and the after bulkhead cut to the same shape; from this mould a fore and aft centre mould must be fixed for the whole length of the cabin-top, and it must be of the shape shown in the sheer plan. When these two moulds are in place, two intermediate moulds must be made, having a similar curve to the after mould, but flatter as the centre heights get less at each mould as they approach the forward end. The simplest way to get the proper curve for all the cross moulds, is to make all of them semi-ellipses; taking the width across the cabin top at each mould as the major axis of that particular ellipse, and the height at the centre above the sides as half the minor axis. Then draw the curve of the ellipse in the following manner: Draw the major axis on a suitable piece of wood, and the minor axis through its centre and at right angles to it; then, with half the major axis as radius, and one end of the minor axis as centre, describe an arc of a circle, cutting the major axis in two points, which are called foci. Drive three small nails into the board, one at each focus, and one at one end of the minor axis. Tie a piece of string tightly round the three nails and then withdraw the nail at the end of the minor axis. By placing a pencil inside the string, and running it round at the full stretch of the string, an ellipse will be drawn, passing through the ends of the two axis. The

diagram will show how this is done (*see Fig. 27*), but it is much simpler to do than to describe, and is very useful for many other purposes.

Having got the moulds in place, as shown in the accompanying sketch (*see Fig. 28*), bend three or four battens over the moulds, and fasten their ends to the after mould and the fore end of the cabin-top. By means of these moulds and battens you have now got a framework similar to that on which the boat was built, and the rest of the work is carried out in a similar manner, steaming and bending the beams or timbers inside the battens, and letting their ends into the top of the side-pieces. When bending in the beams, cut rough holes through the cen-

Bending the House Beams

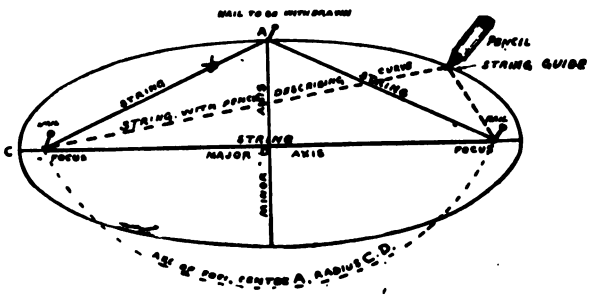


FIG. 27.—METHOD OF DRAWING AN ELLIPSE WITH THREE NAILS AND STRING.

tral fore and aft mould to let them down to their proper places below the ribbands; also put in a stouter beam, twice the sectional area of the others, at the end of the hatchway; but let the rest of the beams run right across the opening, and plank over it. Be careful that the tops of the beams and moulds are kept low enough to allow for the thickness of the planking at the sides and ends, otherwise you will have the planking projecting beyond the sides.

Plank over the beams with narrow ½ in. spruce or cedar, working an ⅛ in. bead on one edge of each plank to show underneath. As soon as all the planking is on and fastened, cut

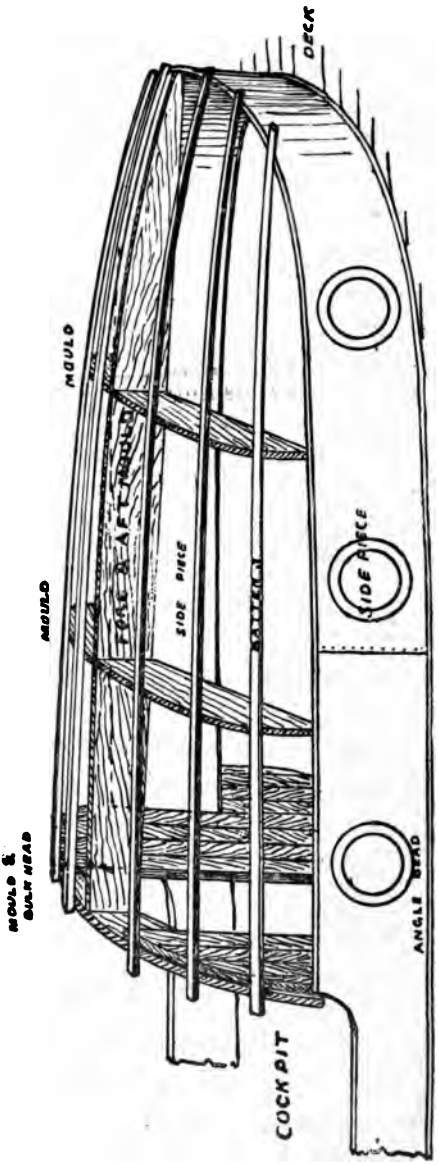


FIG. 23.—CABIN-TOP IN FRAME.

away the moulds and battens, then fit fore and aft carlines of twice the siding and moulding of the beams at the sides of the hatchway, letting them over the beams, and through fasten

them. The after ends of the planks will have been fastened to the after bulkhead at each side of the hatchway, and the ends sawn off flush. The hatchway can now be sawn out to the carlines and after side of the stout beam, and the inside cleaned off.

The cabin top will be cleaned off, stopped, and painted; and the calico stretched over it and painted, in the same way as the deck of No. 1 boat was done; a moulding being nailed over the calico at the joint between the top and sides; and the inside of the hatchway lined with teak to match the slide.

Covering Cabin-top

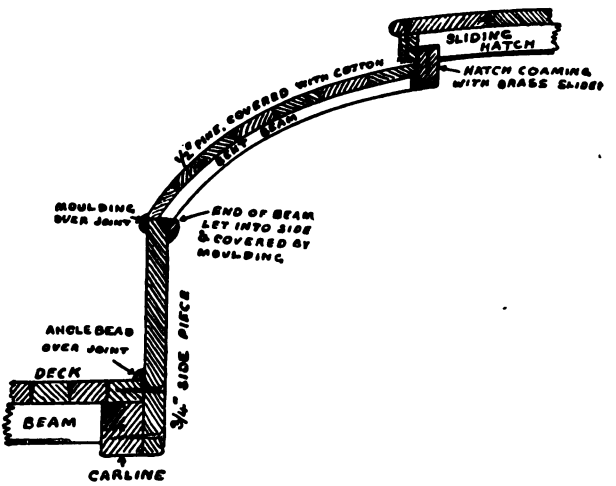


FIG. 29.—SECTION OF CABIN-TOP.

Teak runners, for the hatch, must be screwed over the calico at each side of the hatchway, with brass plates on the top, as shown in the sectional sketch. (*See Fig.* 29.) They should extend the whole length of the cabin-top to form hand rails; but the runner plates should only go far enough forward to let the slide open to the full extent of the hatchway.

Sliding Hatchway

A band of half-round brass, or galvanized iron, 1 in. wide and $\frac{3}{8}$ in. thick, should be worked from the deck beams, up the inside of the sides, along the under side of the stout

hatchway beam, and down the other side to the deck beams again. This band must be well screwed from the inside to deck beams, carlines, cabin-tops, and sides, and to the hatchway beam, and it will then tie the whole structure firmly together.

Making an Oval Hatch

Where an oval hatchway is required, the hole must be framed in the same way as the fore-end of the opening in the deck for the cabin-top, and coamings must be steamed to the curve and scarphed. They should be in two thicknesses with the joints on opposite sides, and the inner thickness should stand 1 in. above the outer thickness to form a rabbet for the hatch to fit over. The rim of the hatch is shaped out of the solid in four pieces, and screwed to the under side of the hatch. A small strip of brass on the top of the inner thickness of the hatch coaming, and a similar strip on the under side of the rim of the hatch, will keep everything in place, and make a neat finish.

CHAPTER IX.

Caulking, Stopping, and Painting.

THE seams of the planking and deck, when the latter is not canvased, should be caulked with cotton, which may be obtained in balls ready for use from the ship chandler or yacht fitter.

Go over the seam to be caulked, with a small caulking iron, so as to open it sufficiently to receive the cotton. Then, starting at one end of the boat, drive the cotton into the seam, twisting it lightly as you drive it in, and taking care not to bruise the edges of the seam. When driving in the cotton, place the caulking iron across the yarn and draw it over the seam, leaving a little slack between each drive of the iron, so that at first the yarn appears to be in short loops in the seam. These loops are then driven in, and the whole hardened down with a narrow, hollow-edged iron, which will level the cotton and leave the seam ready for stopping. Do not drive the cotton in too tightly, when first working it along the seam, or you may force it through the planking. A well-made seam should show a smooth surface of hard cotton, about an eighth of an inch below the surface of the planking. It is important that the cotton should be as even as possible and free from lumps. These can only be avoided by care in placing the cotton in the seam when starting, and hardening it evenly. Oakum is used for large seams, where it can be driven tightly, but is not suitable for small yacht work. It is also much more trouble to prepare and to use.

Driving the Caulking

There is a good deal of knack in caulking, and it will be found very tedious at first; but it should be done carefully, or it will not be of much use. If the seams are to be payed,

or filled, with marine glue, the caulking-iron should be dipped in naphtha; but if ordinary putty or white-lead stopping is used, then raw linseed oil is the best to keep the iron from sticking.

Stopping the Seams and Nail Heads

When all the seams of the planking and deck are properly caulked, they, and all nail heads, cracks, and holes of all sorts, must be filled with stopping; all the nails having been previously punched in about $\frac{1}{8}$ in. below the surface of the wood, a heavy hammer or "holder on" being held inside while each nail is punched. When the nails are roved, the end of the "holder on" should have a hole in it to let the nail pass through the rove, clenching it up again, with the punch, and a heavy hammer, against the nail head.

For all painted or varnished work, where oil stopping or putty is used, a coat of priming paint, or varnish, must be given, before the seams and holes are stopped; and the priming, or varnish, must be well rubbed into all the places where the stopping is to go. When this coat is dry get some putty, colored to match the wood, if it is to be varnished (always bearing in mind that the wood will darken with age), or plain white putty if it is to be painted. Force the stopping well into the seam or hole, and scrape off the surface with the putty-knife. Leave it to harden a night, and next day rub it down with glass paper, which should first be rubbed over with whitening, to prevent the stopping sticking to it. The work is now ready for painting, but before speaking of this I will explain the method of paying the deck seams with marine glue.

Jeffery's marine glue is sold by all ship and yacht chandlers, and is in a solid mass in small wooden boxes, from which it must be broken with a hammer, as required. It is then melted in an iron pot, or pitch kettle, over a slow fire, great care being taken that it does not burn, as it will spoil completely if over-heated.

A warm, dry day should be chosen if possible for this work, as the glue will keep fluid much longer than on a cold day. It is dipped out of the melting pot with a long spouted pitch ladle, and poured carefully into each seam, drawing the ladle along the seam at such a pace that the glue runs out and just fills it. When all the seams are payed, pour water over them to harden them, and scrape off all the superfluous glue with a sharp scraper. Look carefully for any "holidays" or gaps in the glue, and pay these over again; after a final scraping, plane up the whole deck, rubbing the bottom of the plane with naphtha to prevent the glue from sticking to it.

Paying Seams with Marine Glue

A well-laid deck, such as I have described, should be kept scrubbed, and not varnished; but if scrubbing cannot be done often enough to keep it white, it will be better to varnish it. All the teak work about the deck should be kept well varnished, and it will form a good contrast to the white scrubbed pine, and black glue in the seams.

When painting or varnishing the boat, use none but the best paint and varnish, which should be specially prepared for yacht work, to stand the water.

Painting and Varnishing

At least four coats of varnish should be used over the priming coat and stopping, with a final coat of varnish, or paint and varnish mixed. If the work is to be varnished only, it will take six coats to get a good body and surface, and it is very false economy to stint the paint and varnish on a new boat, for if she once gets bare and the weather gets into the wood, it can never be got right again.

Before putting on a coat of paint or varnish, the last coat must be rubbed over with whitening, and well rubbed down with fine glass paper; dust it off thoroughly with a clean dry brush, and wipe over with a damp chamois leather, and apply the paint or varnish *at once.*

Paint should be laid on *thin* and well rubbed in with the brush, finishing as smoothly and with as few brush marks as

possible; but varnish must be laid on *thickly*, and then rubbed in with the brush till it can hardly be moved; but though it is laid on thickly, it must never be allowed to run into streaks, and, above all, see there is no dust about, and that the atmosphere is not cold or damp, or it will never dry with a good gloss.

Painting the Boat's Bottom

The bottom of the boat should be primed, as described above, with but three coats instead of one. Over the priming there should be two coats of anti-fouling composition.

There are many kinds of anti-fouling paints, and of these I should recommend either Blake's "Algycide" or Jesty's Composition. Both of these are applied like ordinary paint, and last very well.

The best coating of all, for salt water or fresh, is copper powder, but it is expensive and troublesome to use. When properly put on, it is exactly like copper sheathing, and keeps bright of itself in salt water, with a perfect surface. The copper powder can be bought at any good oil and color shop, and is used just like gold leaf; that is to say, after the bottom has been primed and rubbed down to a smooth surface, a thin coat of best varnish is put on to the height to which it is intended to carry the copper, then when the varnish is almost dry, or "tacky," the copper powder is applied with a pad or soft brush till all the varnish is covered; when it is softly brushed all over till it is worked into the varnish, and a smooth surface is obtained, like a sheet of metal. When the first coat is quite hard, a second and third coat is put on in the same way, and with three coats properly applied, a boat should be all right for three months.

Applying Bronze Powder

Black lead is applied in the same way as the copper powder, but it has hardly so good a surface, it is not an anti-fouler, and, of course, does not look so well, though much cheaper.

Various enamels and black varnishes are used for the bottoms of racing boats, but they all require a lot of attention,

and do not prevent weeds or barnacles growing, though they have a very fine gloss when freshly put on.

Painting and Varnishing

When painting, or varnishing, always use as large a brush as possible, and one that has been used a little, and got into good working order. A good plan is to buy good second-hand brushes from the local painter, if he can be persuaded to sell them, as they are worth a lot more than new ones, if they have been well broken in.

See that the paint has plenty of oil in it, and not too much turpentine, and that it is fairly thick, but thoroughly strained through muslin, and free from skin and lumps.

Never attempt to paint in the open air, unless it is a fine, warm, dry day, and do not paint or varnish after about two hours before sunset, or the work will be spoilt by the dew and cold air. Frost will prevent any paint or varnish drying properly.

Putting on the Gold Line

It is usual to have a narrow gold line round the boat just under the covering board, if there are no bulwarks. It is in a shallow hollow moulding or groove which is worked in the top strake with a small round plane. The line is marked out with a long batten tacked to the planking and this batten acts as a guide to the plane. The groove should be rubbed down smooth with glass-paper, and primed like the rest of the boat, and when it is all hard and dry it is gilded.

To prepare it for gilding the whole of the paint or varnish work surrounding the part to be gilded is dusted over with whitening to prevent the gold leaf sticking, and the part to be gilded is painted in with gold size and yellow ochre. When the gold size is nearly dry gold leaf is applied, and adheres to the "tacky" gold size, but not to the rest of the boat where the whitening is. It is rubbed lightly into the hollow with a pad of cotton wool or a soft brush, and the surplus dusted off when it is all hard and dry.

Gold leaf can be bought in small books, with each leaf

on a sheet of waxed paper, to enable it to be easily handled. A coat of varnish preserves the gold leaf, but spoils the brightness considerably.

CHAPTER X.

Lead Keels and Centre Plates.

THE lead keel of No. 2 design should be cast at a foundry; but the wooden pattern must be made exactly to the drawing by the boat builder.

When making a pattern, first cut out a set of hollow templates to the sections shown in the design. These are made in the same way as the building moulds; but, instead of the template being made to fit inside the section, as the moulds were, it is made to fit outside, so that it can be tried on the pattern as it is being made. In very large patterns, moulds are used, and the pattern is planked up on them, in the same way as the boat is built; but for a small keel, it is simpler to make it out of a series of 3 in. deals nailed together to make a solid block large enough to cut the pattern from.

Making the Keel Pattern

A full-size drawing of the keel must be made from the sections in the design, and it should have a series of longitudinal sections worked out from the others, at every three inches from the upper side which is to fit next to the boat, and parallel to it. (Note.—These longitudinal sections will not be parallel to the l.w.l.; nor at right angles to the cross sections).

A 3 in. deal should be planed up, and if it cannot be got of sufficient width to make the top piece in one, two such pieces must be joined together. Draw a centre line, and set off the stations for each section, remembering to take all distances of the drawing, along the line of the top of the lead, and not the horizontal interval between the sections, as shown on the

design. Set off the half breadths at each station, draw a fair line through the spots, and saw it out to the required shape.

Mark out and cut a similar 3 in. slab to each of the longitudinal sections, and fasten them all together with their centre lines coinciding; the result will be like a series of steps, the angles of which must be trimmed fair with adze and plane.

Having roughly faired up the pattern, mark the rake of the sections with the upper surface on each side, and try the templates at each section. Be careful not to cut away too much at first, trying the templates several times, planing off a little at a time till they all fit, then fix the pattern temporarily in place on the boat's keel, and fair it up with a batten bent over the planking and pattern, at various angles, planing off any lumps till the batten lies fairly in every direction.

Finishing the Keel Pattern

The pattern must now be finished with a fine plane and glass paper, till it is perfectly smooth; and all cracks and holes must be stopped; it is then ready for a coat of priming, and when that is dry, it should be rubbed down and sent to the foundry.

Most metals shrink in cooling when they are cast, and it is usual to allow for this in making the pattern; but as a lead keel nearly always comes out heavier than it is calculated, owing to the immense weight expanding the sand mould when it is poured in, the contraction may be ignored to some extent.

Do not try to get the bolt holes cast in the lead, but bore them with a shell-pointed auger from inside the boat; this will insure the bolt holes being in their proper places with regard to the floor frames.

Boring Bolt Holes

Boring the lead is a tedious job, and requires an auger properly sharpened, or it will stick in the hole. A twist auger is quite useless for lead, and will stick at once, and probably break in the hole. Use plenty of oil or soapy water as a lubricant when boring lead.

When boring these bolt holes, from inside the boat, great

care must be taken to get the boat plumbed exactly upright; so that a plumb line inside the boat will show the proper direction for the auger, to get the hole in the centre of the lead. Be sure to start your auger perfectly plumb, and once the hole is a few inches deep the auger cannot go wrong.

A lead keel is far too heavy to move about single handed, and help must be obtained to place it in position, and wedge it close to the wood keel ready for boring; but before it is in place, the upper part must be levelled to fit the wood. This is done, first with an adze, and afterward with a plane. A heavy hammer will often reduce a small lump, and if the lead is bent, it can be straightened by laying it on blocks of wood, and striking it with sledge hammers (with a piece of wood over the lead to prevent dents). The bolts for the lead keel should be of Bull's metal or Tobin bronze, with long, tapered, square heads, and driven from below. They should be fitted tightly through the wood keel, but the holes in the lead should be large enough to let the bolts drive fairly easily.

Fitting the Keel

The end filling pieces of wood to carry out the form of the keel, are fitted after the lead is on; and the whole dubbed fair with the adze, and planed up when bolted together.

Take plenty of time over fairing up the keel, as on this depends much of the boat's speed.

Paint well between the wood keel and the lead and all joints.

For those who wish to cast their own lead keels or bulbs, the following hints may be of use, but I should strongly advise anyone to get the lead cast at a foundry, as it is a very troublesome business, and requires a good deal of care to turn out a good casting.

To make a mould for a lead keel of the size required for No. 1 design, about two cart loads of moulders' sand must be obtained from a foundry, ordinary sand being useless, having no cohesion. There are two methods of making the mould,

first (and best) by digging a hole in the ground about 6 in. deeper, a foot longer, and a foot wider than the pattern to be cast, and filling it up with the moulding sand round the pattern. The second way is to build a strong box of 3 in. deals to contain the sand, but without either top or bottom. This box is filled with the sand round the pattern in the same way as the hole in the ground, but is liable to burst with the weight of the lead, and requires a special trough or shoot for the lead from the furnace or melting pot, whereas the other form of mould simply has a gutter cut in the sand, along which the lead flows. The advantages of each of these are cheapness, simplicity, and perfect strength and safety of the first; as against portability of the mould, ease of handling and getting out the casting, and possibility of using the mould on a wood or brick floor, with the second method. The mould box must be very strongly made to stand the enormous strain of the lead.

Making a Keel Mould

Whichever plan is chosen, the method of making the mould will be the same. Fill the hole or box about six inches deep with moulding sand, well rammed down as hard as possible; ramming each layer of say an inch in depth, till the whole mass is solid. Place the wooden pattern on this bed of sand, with the top face, which is to fit next to the wood keel, exactly horizontal, and levelling it carefully in all directions. Before placing the pattern in the sand, fill up the scarph in the after end with a block of wood, 2 in. wider each side than the rest of the pattern, and level with the top and after end; it should be held in place while the sand is being rammed round the pattern, and must be removed before the main piece. Support the pattern exactly in position, and pour in sand, ramming it tightly as it is put in, till the whole mould is full and a bit above the level of the top of the pattern. Take a trowel and level the sand exactly to the surface of the pattern, and cut a groove or gutter for the lead to run into the mould at the

thinnest end; the pattern can now be removed, but it should have a couple of screw eyes in the top to lift it out of the sand. Before lifting it out, tap it all over sharply with a hammer, to loosen it in the sand, and then, first removing the loose block from the scarph, lift it out carefully and slowly, so as not to injure the sharp edges and angles of the mould. When the pattern is removed the loose block in the scarph will have left a gap in each side of the sand 2 in. wider than the rest; a plate of sheet iron bent up at the fore end to fit the scarph, is now placed over the gap, and covered in with sand, till all is firm and level. These instructions only apply to patterns which taper, and therefore can be easily withdrawn from the sand. Bull-shaped keels must be cast in a mould in two halves; this is beyond most amateurs' power to make, as it requires special boxes to contain the sand, and considerable skill in moulding, to turn out such a casting.

Removing the Pattern

Having prepared the mould, a melting pot or furnace must be constructed. This should consist of an iron pot (wrought iron for choice), which will hold at least a ton of lead, but, if possible, large enough to contain the whole amount required, and a few cwts. extra for waste. This melting pot must be set in a ring of fire bricks, with one or two openings at the bottom for firing, and several more on top to create a draught; or it may simply stand on three fire-brick piers, and have an open fire all round it. In either case, a large coke fire will have to be maintained for some hours, under and round the melting pot, which should be filled with lead in as small pieces as possible at first, larger pigs being added as the mass of melted lead increases, till the whole amount is melted, or the pot is full. A pouring hole or tap should be fixed in the bottom of the pot if possible, and should consist of a hole or pipe about 1 in. in diameter, which is stopped from the outside with a clay plug to be knocked out when the lead is ready to pour. A gutter is made from this hole to the runner, or

Melting the Lead

groove, in the mould, the whole being on a good slope; so that the melted lead flows freely.

Pouring the Lead

If a melting pot with a pouring hole or tap cannot be obtained, a common cast-iron pot can be used, and the lead dipped out in long-handled ladles, and poured by hand into the mould. This is very trying work, owing to the great heat of the fire, and several hands must be employed to pour in the lead fast enough to keep it melted in the mould till it is all in; as, if it partly cools, a division or flake will occur, and spoil the casting. In no case is it possible to obtain such a good casting by means of hand ladles as by running direct from the melting pot, though a twenty-ton keel, cast entirely by hand ladles, turned out fairly well.

To get a really good casting, the lead should be very hot and fluid, and run into the mould as quickly as possible; also all dross and scum will be avoided if it is run from a hole at the bottom of the pot. The hotter the lead is when run, the denser the casting will be; and consequently the casting, which is run very hot, will probably come out a bit heavier than one run at a heat when the lead will only just pour. A little resin should be thrown into the pot just before running as a flux. Don't forget that a casting of a ton or more will take many hours to cool. An alloy of one part antimony, to four parts lead, is very much harder than pure lead.

Ordering the Centre Plate

The centre plate must be ordered from the smith with the other iron and metal work; and a full-size template of thin wood should be made to the drawing, with all holes and sharp edges, etc., marked clearly on it. Particular instructions should be given with the order, as to sharpening the edges, and also stating that the plate must be absolutely flat and true; a bent or buckled plate is quite useless, and cannot be straightened by an ordinary smith.

The edges should be sharpened to a long easy bevel, which should be carried back on the plate for a distance equal to

three or four times its thickness; dying gradually into the flat surface. The edges cannot be too sharp. Bull's metal or Tobin bronze is the best material for centre plates for all purposes; but it is expensive, and often sent out very badly buckled, unless specially ordered to be planished; there is often considerable delay in getting the plates. Next to this metal, saw-blade steel is the best for very light plates, or mild steel for heavier plates which are to be galvanized. Do not try to galvanize saw steel, or it will buckle badly and cannot be straightened.

Material for Centre Plates

The above remarks apply equally to all centre plates of any form, and also to bulb fin plates and rudder blades.

There are four types of centre plates now in general use, and many modifications of these general types. In addition to these there are lifting bulb fins and ballasted centre plates, which most of them come under one or other of the four main types.

Types of Centre Plates

These four classes are: 1st, the rectangular, with a vertical hoist, by means of handles, or one or more wires or chains. (*See Fig.* 30.)

2nd, the triangular plate, pivoted at the fore end, and hoisted by a handle, wire or chain, at the after upper corner. (*See Fig.* 31.)

3rd, the semi-circular plate, pivoted in the centre of its straight edge or diameter, and hoisted by a handle on one end; the slot in the keel may be only half the length of the plate, the case inside being the whole length. This is the easiest plate to raise of its weight. (*See Fig.* 32.)

4th, and most generally used now, the deep rectangular or knife-shaped plate, (commonly called a "dagger" plate), and lifted by a tackle from a lever arm on the forward upper corner. (*See Fig.* 33.) This plate was introduced in this country by the writer in 1894, in the 1-rater *Sorceress,* and is very effective, but requires a long case and slot in the keel.

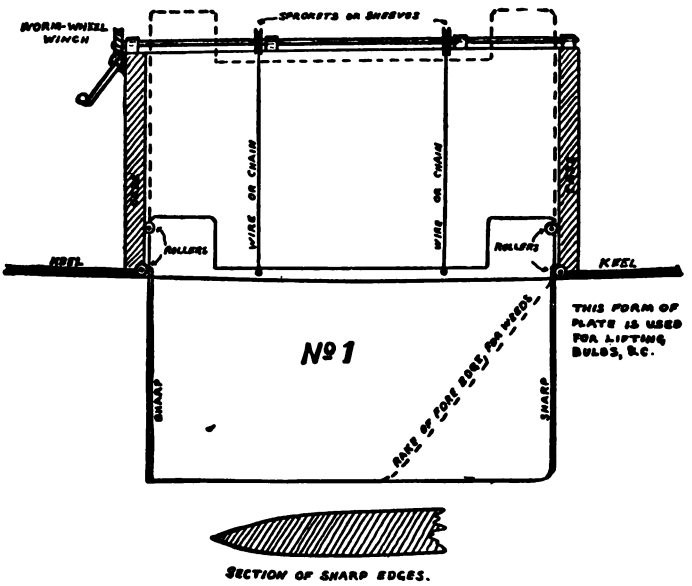

WORM-WHEEL WINCH
SPROCKETS OR SHEAVES
WIRE OR CHAIN
WIRE OR CHAIN
ROLLERS
ROLLERS
KEEL
KEEL
THIS FORM OF PLATE IS USED FOR LIFTING BULBS, &c.
№1
SHARP
SHARP
RAKE OF FORE EDGE FOR WOOD
SECTION OF SHARP EDGES.

FIG. 30.

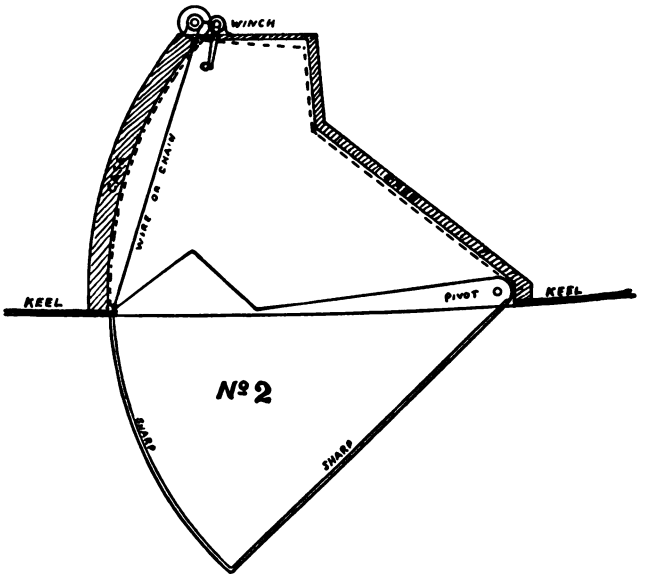

WINCH
WIRE OR CHAIN
KEEL
PIVOT
KEEL
№2
SHARP
SHARP

FIG 31.

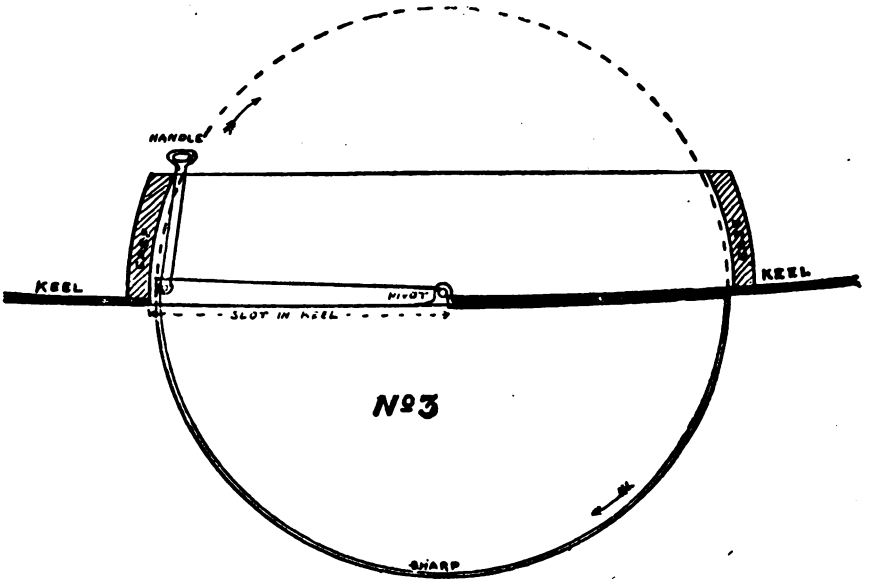

HANDLE
KEEL
PIVOT
SLOT IN KEEL
KEEL
No 3
SHARP

FIG. 32.

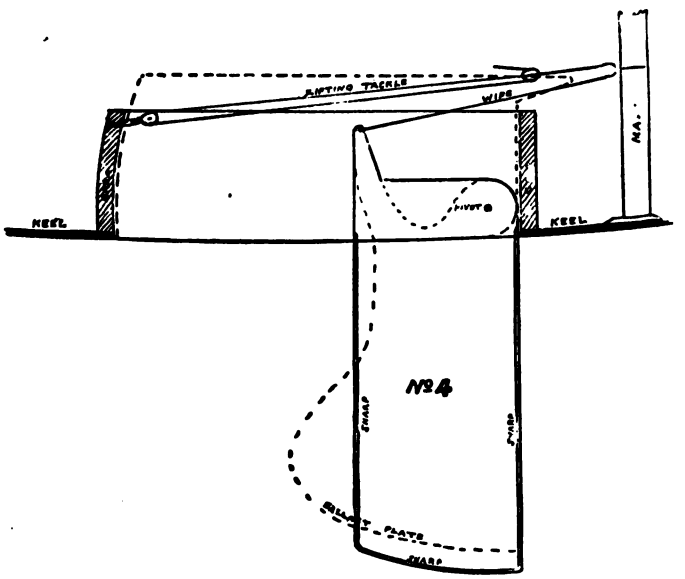

HOISTING TACKLE
WIRE
MA.
KEEL
PIVOTS
KEEL
No 4
SHARP
SHARP
SHARP

FIG. 33.

This type has been used in many shapes, from the original knife form of 6 ft. drop and 2 ft. wide to a plate of only 3 ft. drop and 2 ft. 6 in. in width. The object of the shallow plate in this case was to evade the tax (under the French rule) on the radius of the plate taken from the pivot to the furthest point in the plate. The semi-circular plate, No. 3 type, evades this rule very well, and was used in an Italian boat.

Centreboards

The first type of a rectangular plate, though not nearly so effective for a given area and weight, is essential under a rating rule which taxes the vertical drop of the plate heavily, and is also the best form for a lifting bulb or ballasted plate.

The triangular plate lifted from the after end is hardly ever seen now, as it is ineffective for its size, as compared with the 4th class of plate, and does not conform well to the rating rules, like the 1st and 3rd classes. This plate is in use only on very weedy waters, where a plate with a vertical or nearly vertical fore edge could not be used; even when it is used now, it is usually lifted from the fore end like the No. 4 type.

The fore edge of the No. 1 type is sometimes cut to a sharp angle to get rid of weeds, but of course it leaves a gap in the fore end of the case, when raised; unless it is raised in a direction parallel to the fore edge, which requires a long case forward of the slot in the keel.

Of the lifting bulbs, or ballasted plates, the simplest and most efficient is the No. 1 type plate, with a raking fore edge to clear weeds, etc., and a lead bulb of pear-shaped or cigar-shaped section and suitable weight. By means of such a plate, a small boat can be made uncapsizeable, and carries her ballast in its most effective form, while she is not debarred from shoal waters as a fixed bulb keel boat would be; the only disadvantage of this form being that the bulb projects below the keel when the plate is housed, unless a very large slot is cut in the keel and a wide box case fitted, with some form of

Lifting Bulbs

self-closing arrangement to stop up the gap in the keel, and hold the plate firmly when it is lowered. This is best done by having a loose wooden block on each side of the plate weighted sufficiently to keep it at the bottom of the case, till raised by the top of the bulb striking it on rising, and prevented, by a slightly overlapping keel band, from falling through the slot when the bulb is down. These blocks must be hard wood, teak for choice, and at least twice their width in depth to prevent them from jamming in the case.

Lifting Bulbs

Such a ballast plate as this should be lifted by two flat link, bronze bicycle-pattern chains, passing over sprockets on a central spindle along the top of the case, the latter being actuated by worm-wheel gear. By gearing of this sort, a bulb and plate up to several tons may be lifted, but the whole affair is very costly, and requires a good builder to fit it, and can only be made by a competent engineer.

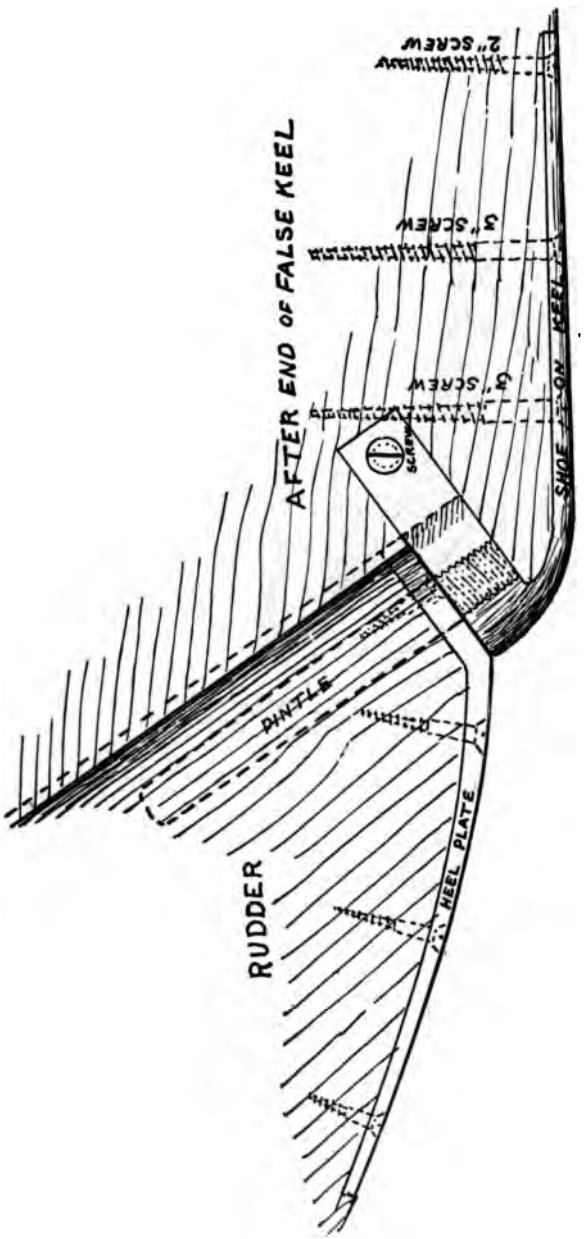
CHAPTER XI.

RUDDERS.

THERE are two principal forms of rudder construction now in general use, the first and oldest method being to cut the stem and main piece of the rudder blade out of one solid piece of oak, bolting a second piece of the same wood on the after side of the main piece to make up the full area of the blade. This is the simplest way to make a rudder; but such a rudder is very thick and clumsy, and if not made rather heavy, is likely to be weak in the neck, where it enters the rudder trunk. It also necessitates a large rudder trunk and a thick stern post. It is a very good form of rudder for larger cruising yachts.

Rudders

The second and modern method is to make the stem of the rudder of a thick steel tube (or of a solid round steel rod); the lower end, where it is attached to the blade, being split into a fork, and riveted on each side of the blade; the latter may be either of wood or metal. The upper end of this form of stem is plugged with a piece of solid steel, and has a thread on it, with a large flat nut, to form a collar on the deck bearing; and above this is a tapered square to take the tiller, with a thread and nut above it, to hold the tiller in place. It is neater and stronger than the first method, and only requires a very small trunk. As mentioned in the chapter on rudder trunks, a plain piece of tube, screwed into the keel or counter-frame, with a flange on deck, is all the trunk required for this form of rudder stem; when the rudder is not liftable, or attached to the stern-post.



HEEL BEARING (No 2 DESIGN)

FIG. 34.

Rudders

The rudder of the No. 1 design would be equally suitable for a non-liftable rudder. It is composed of a steel tube stem, 1 in. diameter, split at the lower end into a fork, with two arms 1 ft. 2 in. long, which are riveted on each side of an $\frac{1}{8}$ in. steel blade of the shape shown.

A shaped piece of teak or other suitable wood, is fixed

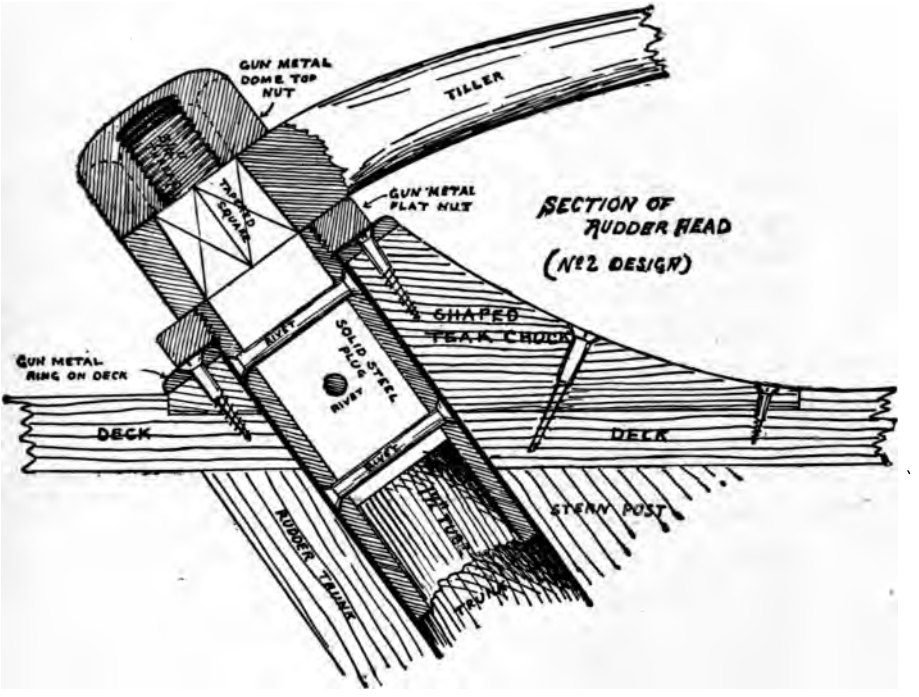


FIG. 35.

on the deck at the top of the rudder trunk, and has a gun metal ring let into its upper surface to form a bearing for the top of the rudder stem, the flat nut which rests on this ring, and takes the weight of the rudder, when it is not attached to the stern-post.

The method of constructing the rudders of both the designs is clearly shown on the drawings. The only particulars in which the stern-post rudder in No. 2 design differs from

the one described above is that it has a stouter tube for the stem and a hard-wood blade, the thickness of which is equal to that of the stern post, on the fore edge and tapers to half an inch or less on the after edge. It is also fitted with a heel bearing, (*see Fig.* 34), consisting of a gun metal pintle

Rudders

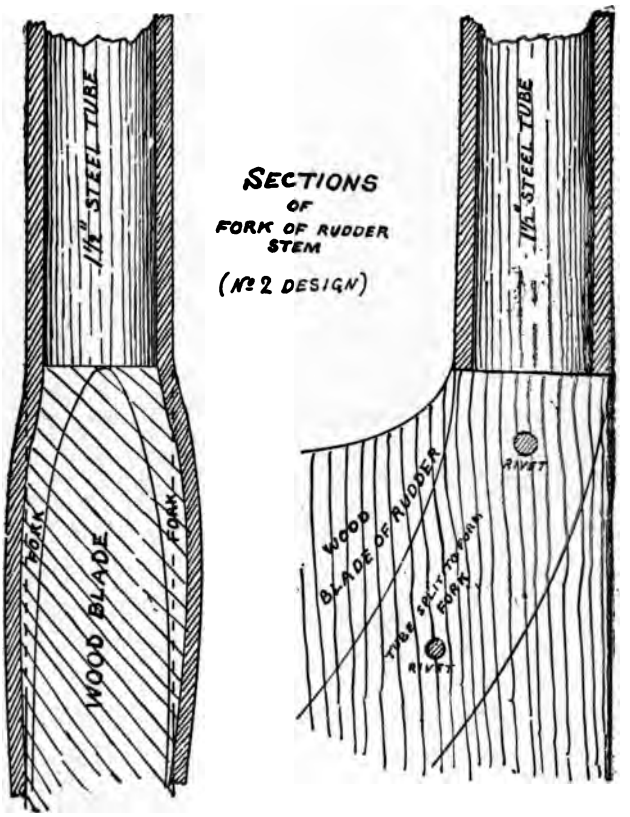


FIG. 36.

screwed into a heel plate on the keel of the boat, and working in a gun metal socket fixed to the bottom of the rudder blade. There is also an intermediate strap of metal through a hole in the blade and let in flush in each side of the stern-post.

The fore edge of the rudder must be rounded to fit a

corresponding groove in the back of the stern post, and the hole for the intermediate strap bearing must form a circle with the rounded fore edge, for the strap to travel freely as the rudder turns.

Rudders

The accompanying detail drawings show the method of fitting the rudder head, fork, and intermediate strap and heel bearings of the No. 2 design. (*See Figs.* 35, 36 and 37.) The details of head, stem and fork for No. 1 design will be the same as in No. 2, but slightly smaller, and a plain steel blade will take the place of the wood. When the tube is split to form the

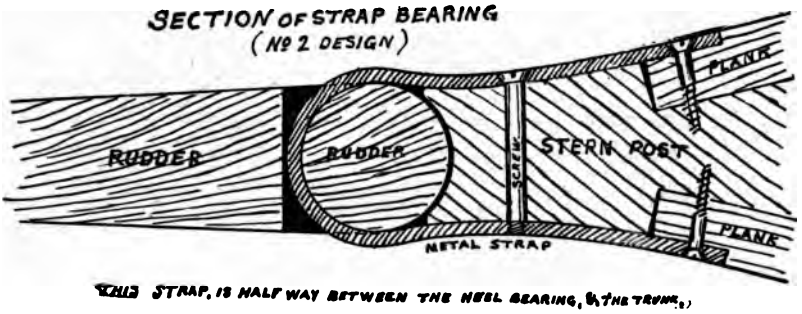


FIG. 37.

fork, which should be done with a saw, it should not be flattened close to the upper end, but gradually taper from the round tube into flat ends, the hollow in each fork being filled in with a piece of hard wood before the blade is riveted in place.

There are many other methods of fitting rudders, but the one illustrated is the simplest and strongest. In either boat a solid steel rod may be substituted for the tube as a stem, but it must be reduced in diameter to about three-quarters of that of the tube, or it will be too heavy. It is cheaper to make than the tube stem, but much heavier for a given strength.

CHAPTER XII.

Spars.

THE spars of most small yachts and boats are made from Norway spruce, which is imported in the form of rough natural spars of all sizes, and can be obtained at any timber merchant's.

Bamboo spars are most suitable for small raters, and for spars of 4 in. to 5 in. diameter; they are stronger and lighter than any others, but can only be obtained in standard lengths. They are very liable to split in hot weather. The usual stock sizes are as follows:—

Masts.—4 in. to 6 in. or 6½ in. at butt; and 33 ft. to 35 ft. long (considerable taper).

Masts, booms, yards, and small spars.—3 in. to 3½ in. at butt; and 22 to 25 ft. long; 2 in. to 2½ in. at butt; and 18 to 22 ft. long (fairly parallel); 1 in. to 1½ in. at butt; and 18 ft. long (either parallel or taper).

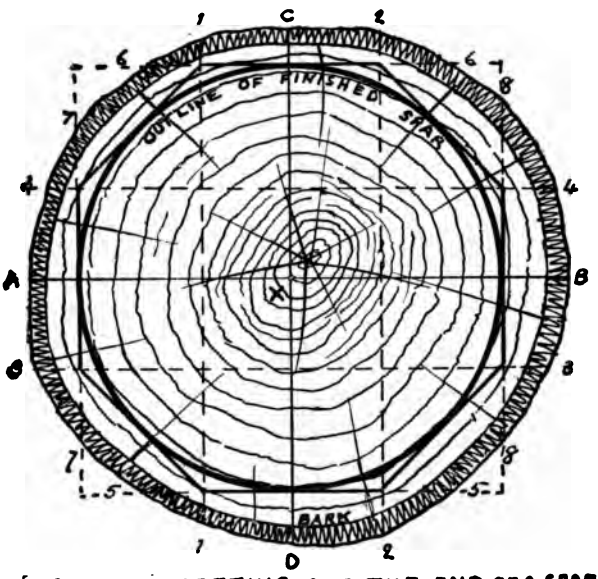
These canes should be carefully selected from the bales, and it will take an hour or two's dirty work to pick out a set of first class sticks, which are all free from cracks, and perfectly straight. It is well worth while to enlist the sympathies of the foreman when undertaking this task, and a few shillings to the men who turn over the canes are not wasted, as they can tell a sound cane where a novice would not.

Selecting a Bamboo Spar

In preparing a bamboo spar, all knots or joints should be rasped down smooth, and a small whipping or binding of fine twine may be put on between each joint. This whipping may be omitted in the case of a really good cane, but it is very

difficult to tell when a cane will split or not. The ends of all bamboos should have a light metal ferrule or wire whipping on them, as they must be plugged with pine and would split at once if nothing were put on the end. The plugs should be cut to fit the inside of the cane exactly, and should have a shoulder on them to rest on the end of the bamboo. A hole may be bored up the inner end of the plug to lighten it if desired. A hole through all the webs of the joints down the centre of the

Preparing a Bamboo Spar



METHOD OF SETTING OUT THE END OF A SPAR; READY FOR SAWING, OR WORKING UP WITH THE DRAW-KNIFE.

FIG. 38.

cane is supposed to prevent splitting; but, while it is probable that it may often save a split, it is not proved to be a positive cure for the trouble. Keep bamboos in a cool, airy place, never bore holes in the shell of the cane if it can be helped, and do not attach any gear or fittings to them, except by bands or wire strops.

The Canadian hollow spars are very neat, and nearly as

light as bamboos of the same size, but not so strong weight for weight as a bamboo, up to 4 or 5 inches in diameter; their great advantage over bamboos is that they can be ordered of any shape, proportion or size, while a bamboo can only be obtained of the stock sizes given above, and you must take it with whatever taper you can get. Spars

Both bamboos and hollow spars must be kept well var-

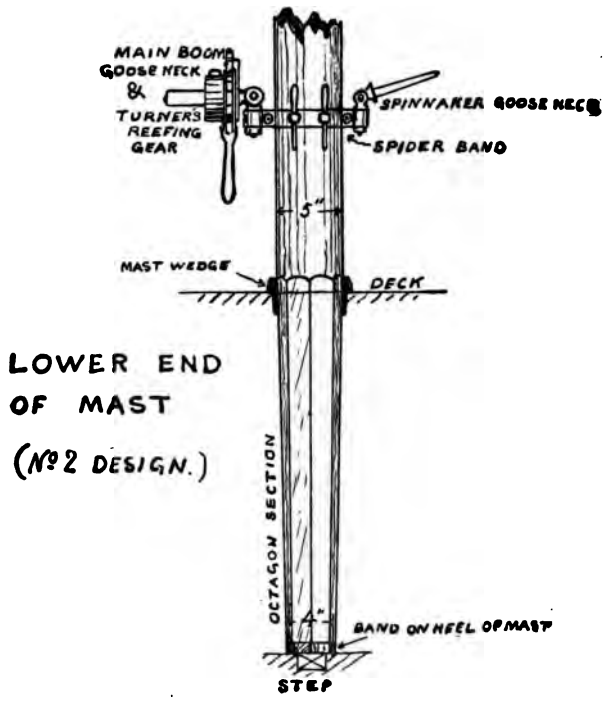


FIG. 39.

nished to avoid splitting, and this also applies in a less degree to all spars and woodwork. I should not advise the use of anything but solid grown Norway spars for cruising work, except for a jib-roller or topsail yard; a bamboo makes the best jib-roller possible up to about 22 ft. long, as it keeps its shape far better than any built or hollow-wood roller, and is stronger. The

Spars

joints of bamboo rollers are generally knocked out with a long ½ in. iron rod, to the end of which the roller wire is attached, and

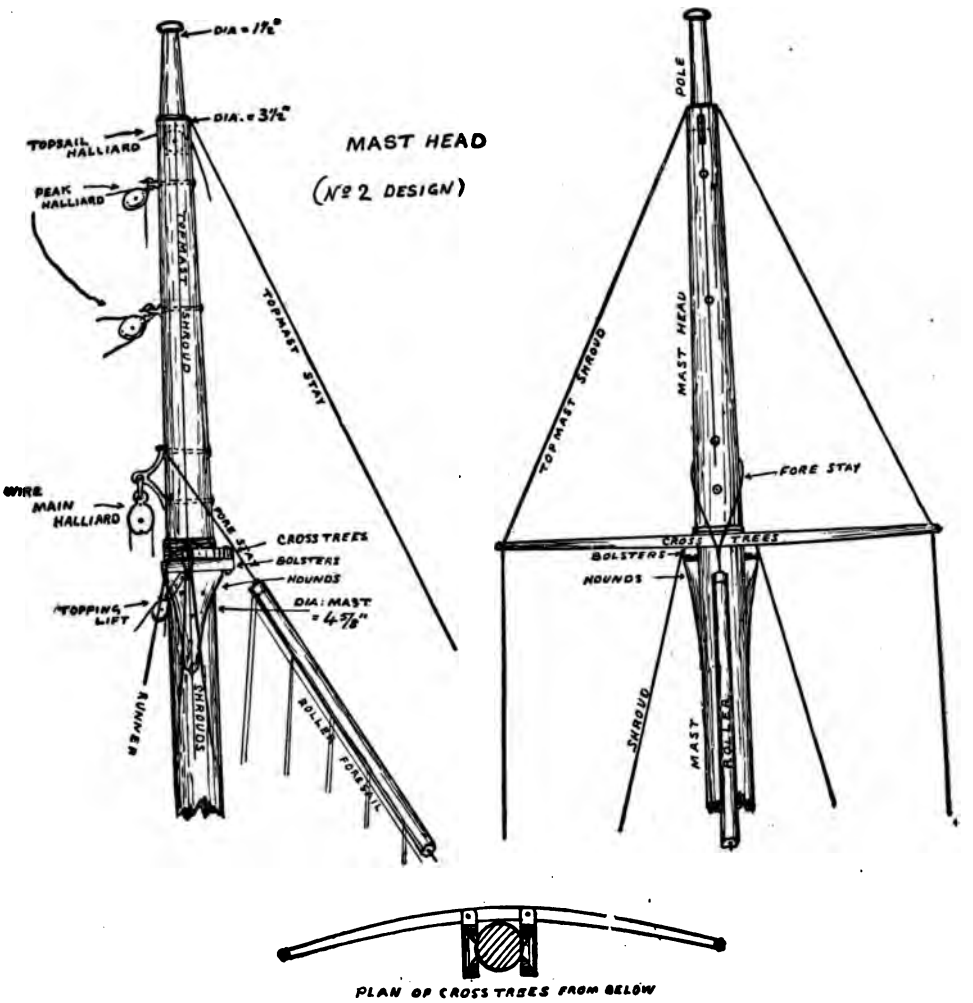
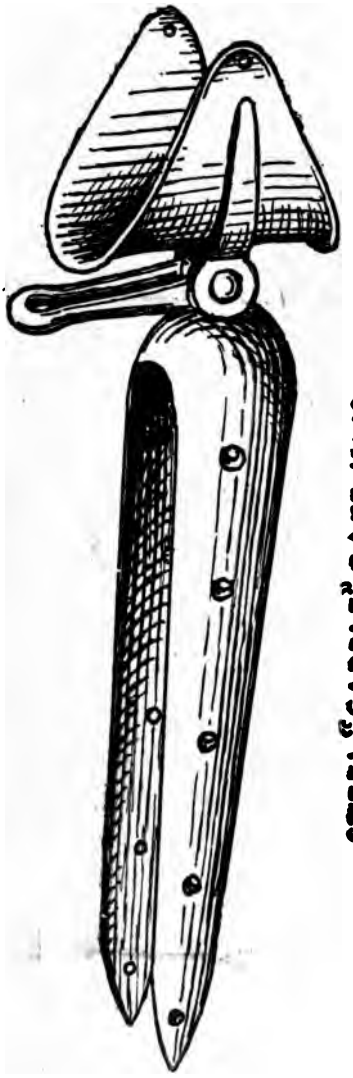


FIG. 40.

the whole affair passed through the cane from end to end. This should be done with the cane in a vertical position if possible, as the weight of the rod will help to break through the joints,

and it is more likely to go through the middle of the joint than it would be if the bamboo were horizontal. Spars



STEEL "SADDLE" GAFF JAWS.
FIG. 41.

When choosing Norway spars pick those with the smallest knots and finest grained bark; strip off some of the bark and see

Spars

that the wood is a clean yellow color. If it is a very dead white, the spar is usually wanting in toughness; but if the grain is very marked, and the color a dark, reddish yellow, the spar,

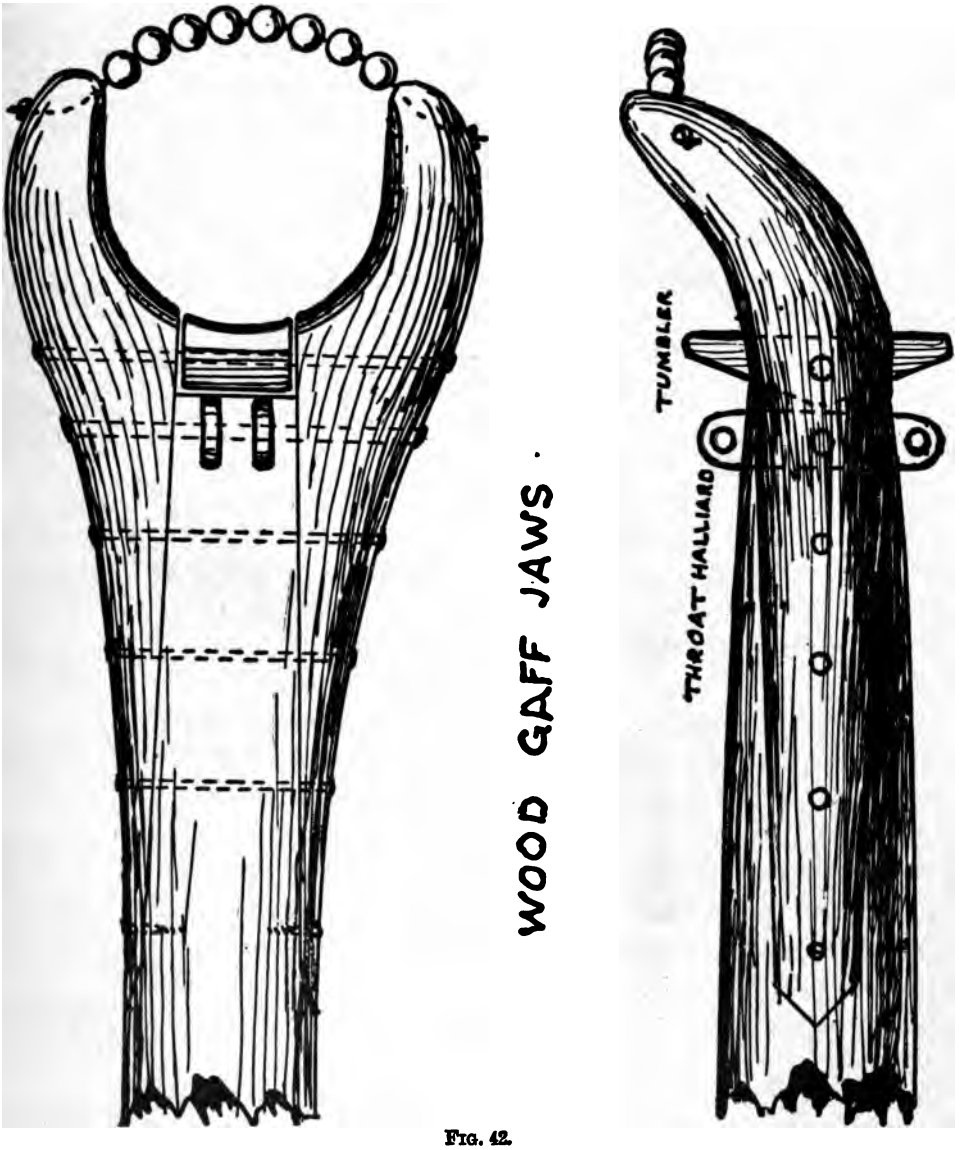


FIG. 42.

though probably strong and tough, is sure to be heavy; avoid bluish spars. Spars

All the spars should be picked as near the finished size as possible, so as to avoid waste, and also because the outer part of the spar is the toughest; select the straightest spars.

Clean all the bark off the spar and set out the finished diameter on the butt end as shown in the diagram. (*See Fig.* 38.) To do this draw two diameters A-B and C-D at right angles to each other, crossing in a central point ×; as near the center of the rough spar as possible. With × as center describe a circle

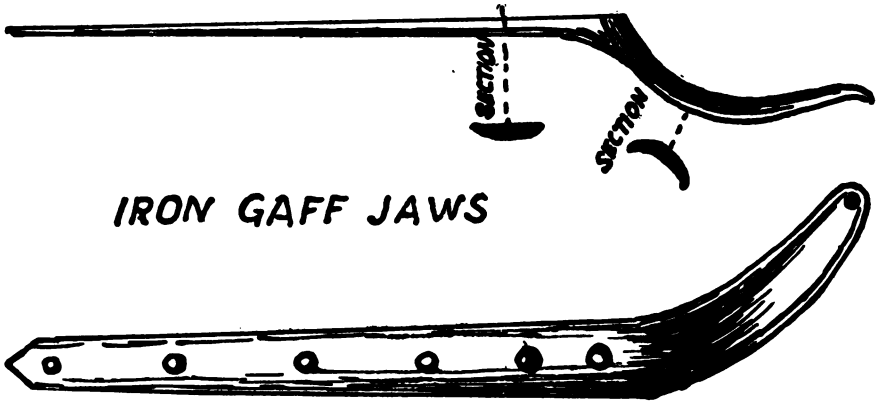


FIG. 43.

with a pair of compasses, of the same diameter as the spar is to be, at the largest part; say 3 in., then draw two lines 5-5 and 6-6 parallel to the diameter, A-B, and just touching the circumference of the circle. Draw two more lines 7-7 and 8-8, parallel to the other diameter, C-D, and at right angles to the other lines. These four lines would, if the rough spar was large enough, form a square exactly containing the required circle of the finished spar, but as the rough spar is chosen as nearly as possible the proper size, the corners of the square will be absent.

To get the octagon as shown, containing the circle, divide

Spars

the diameter of the circle into seven equal parts, and draw the lines 1-1 and 2-2, each $\frac{2}{7}$ from the ends of the diameter A-B,

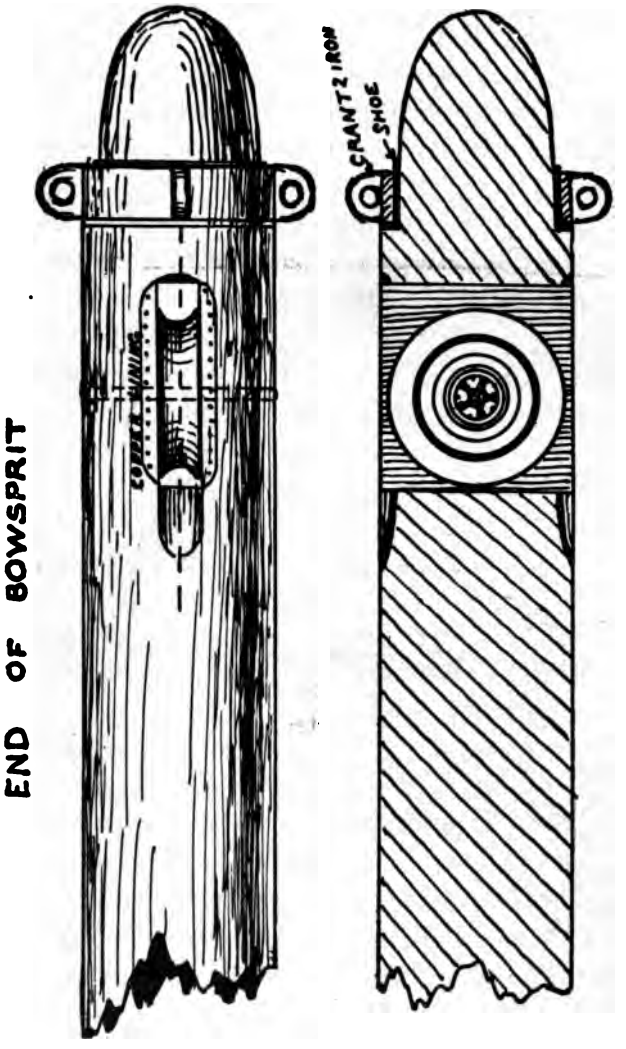
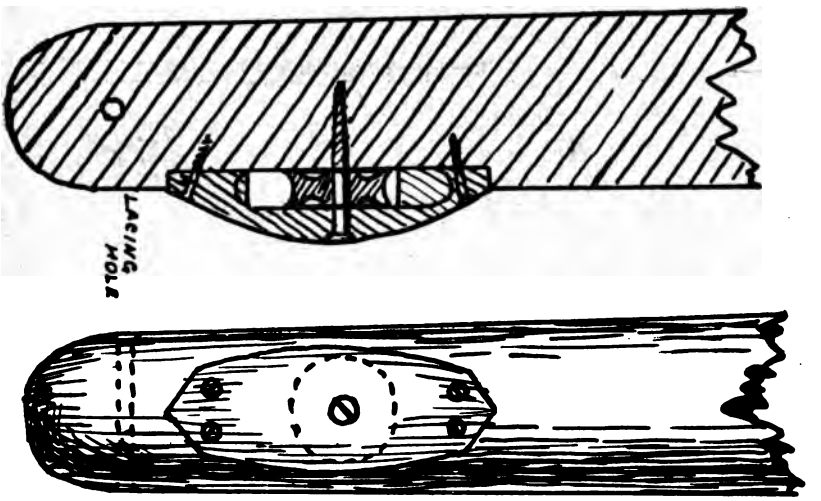


FIG. 44.

and at right angles to it; and the lines 3-3 and 4-4, in a similar manner on the diameter C-D. The points where these four

lines intersect the squares first obtained will be the angles of the octagon. Spars

Both ends of all spars should be set out in the foregoing manner to their respective sizes, a center line being marked on the outside of the spar throughout its length. All the various diameters should be set off, half on each side of this line at their correct distances apart. A chalk line is then struck along the lines 5-5 and 6-6 from one end of the spar to the other, but,



CHEEK SHEEVE AT END OF GAFF

FIG. 45.

of course, at the various diameters for the different parts of the spar.

The spar is now put in a saw-mill, and the slabs outside the chalk lines cut off; or, if no saw mill is convenient, this may be done with a draw-knife or adze. The spar is then roughly squared to the requisite sizes throughout its length, and the lines 1-1, 2-2, 3-3 and 4-4 for the angles of the octagon must be set off for the whole length, the wood cut away with the draw-knife as before; then plane up all the eight faces and finish the rounding, first with a jack plane, and finally with a hollow-soled, spar-

Spars

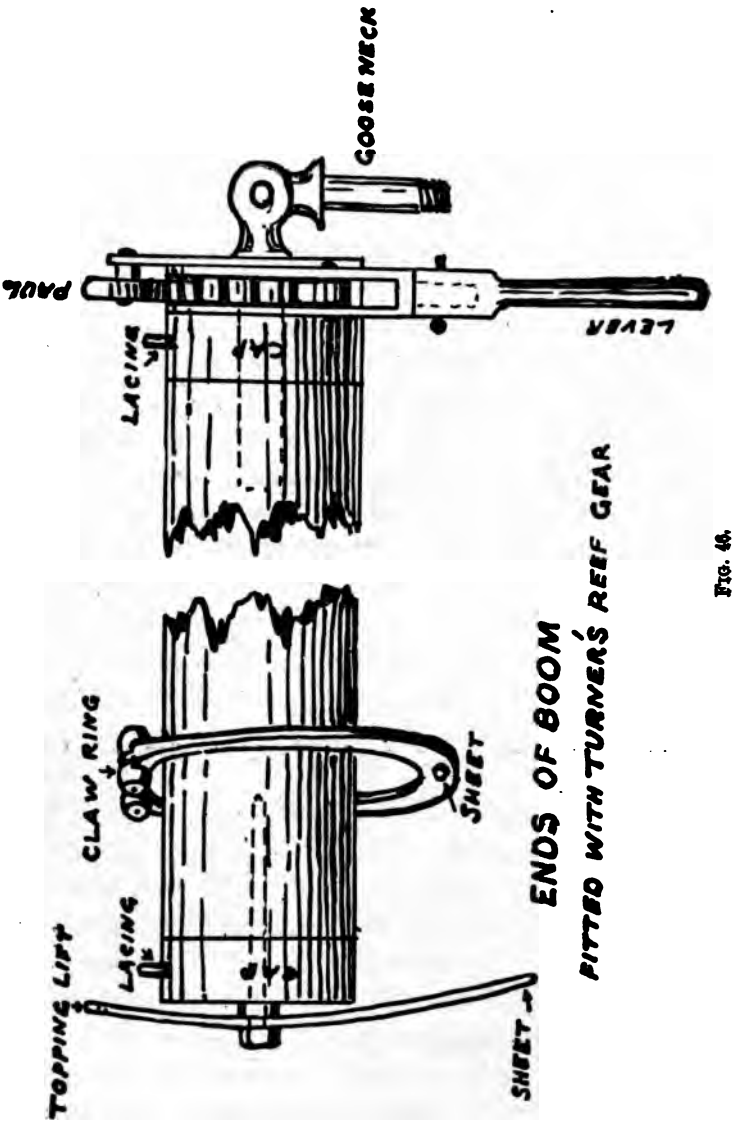


FIG. 43.

maker's plane and glass paper. The lower part of all masts which pass through the deck should be left octagonal in section, and must taper to the step, as shown. (*See Fig.* 39.)

The accompanying detail sketches (*see Figs.* 40, 41, 42

and 43) show the various methods of fitting the ends of the different spars, with the exception of the roller for a roller head sail, which is illustrated fully in Part II, under the heading of "Reef Gears." Spars

The drawing of a bowsprit end will be equally suitable for the head of the mast in No. 1 design, except that in such small boats there is no need for a crantz iron and shoe. (*See Fig.* 44.)

Of the three patterns of gaff jaws, the iron or steel saddle jaws are far the best, and can be obtained ready made.

The sketch of the cheek sheeve in the end of the gaff will also apply to the method of fitting the hounds on the mast head in No. 1 design. (*See Fig.* 45.)

Turner's reef gear is shown on the boom ends (*see Fig.* 46), but if not required, a simple gooseneck and cap at each end, of the same pattern, would answer very well. I would strongly advise reef gear on all booms in small yachts.

NOTE.—The following are the usual proportions of diameter to length for solid spars, but hollow spars and bamboos should be 10 per cent. greater diameter than solid spars of the same length.

Masts.—Length × .022 = diameter at deck.

Diameter at hounds 10 per cent. less than at deck for pole masts, or equal diameters at deck and hounds for a lower mast carrying a topmast.

Diameter at step 15 per cent. less than at deck; the step should be the largest square contained in the circle of the lower end of mast at that point.

The depth of step should be not less than half its diameter.

Booms.—Length × .016 = diameter at sheet. For Turner's or other roller reef gear the boom should be as nearly parallel as possible. If a bamboo is used, the smaller end must be next to the mast. Ordinary booms taper from the sheet to $\frac{2}{3}$ at fore end and $\frac{3}{4}$ or $\frac{5}{6}$ at the after end.

Spars

Gaffs.—Length × .018 = diameter at mid-length, tapering to $\frac{2}{3}$ at the outer end and $\frac{3}{4}$ at jaws.

Bowsprits.—These vary very much, and no fixed ratio of diameter to length can be given.

Spinnaker Booms.—Length × .015 = diameter in centre, tapered to $\frac{3}{4}$ at each end.

Spinnaker Booms on Roller Foresails.—Length × .016 to .018 = diameter.

Rollers for Head Sails.—Length × .014 to .015 = diameter.

CHAPTER XIII.

Deck Fittings and Iron Work.

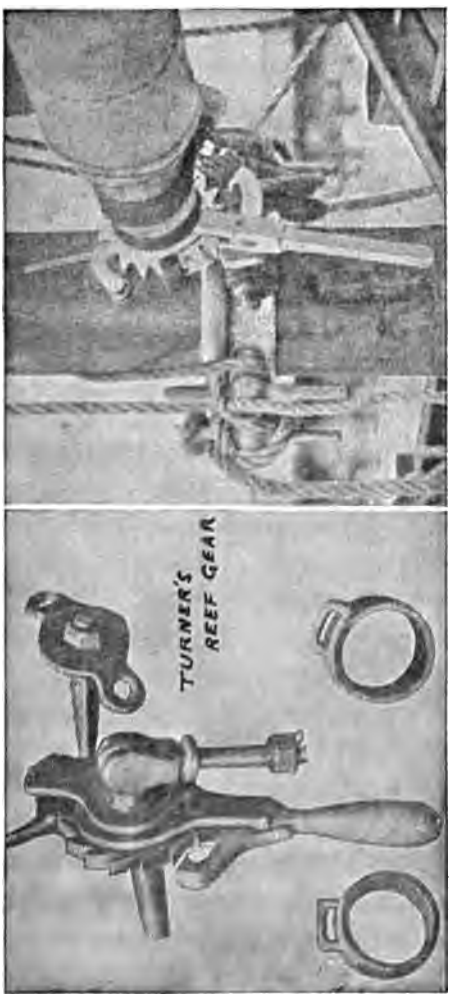
MANY of the deck fittings can be purchased ready made from any of the principal yacht chandlers, and most of the accompanying illustrations are taken from their catalogues. There are, however, several parts of the iron work which must be made to fit the boat by the local smith, such as

BLAKE'S PATENT HOOK. JIB SHEET SHACKLE.

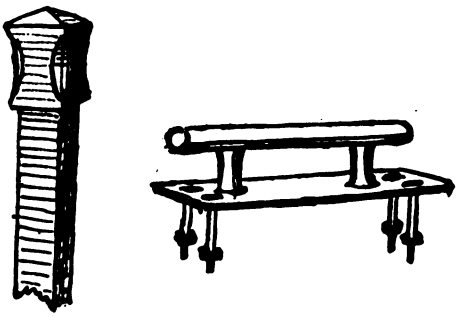
the gammon iron on the stem head, which also carries the chain sheeve for the cable; the strap for the heel of the bowsprit, which takes the place of the old wooden bitts; the shroud and runner plates, bobstay plate, and the pin rail at foot of mast,

Fittings

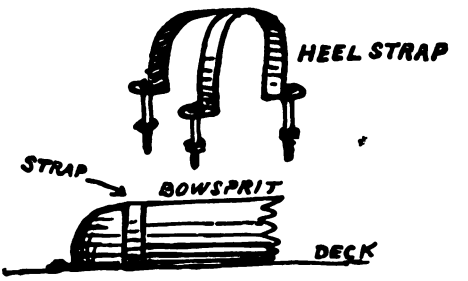
to which most of the running gear is belayed. All these fittings must be made to suit the boat, and fitted to their place by the smith.



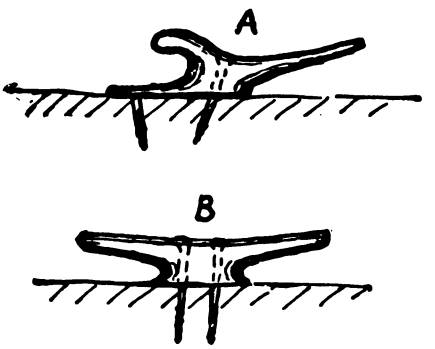
The following deck fittings will be required. (Those which are only for No. 2 design are marked with an *, the remainder being suited for all types of small boats.)



MOORING BOLLARDS



BOWSPRIT HEEL PLATE, OR STRAP.



CLEATS

Fittings

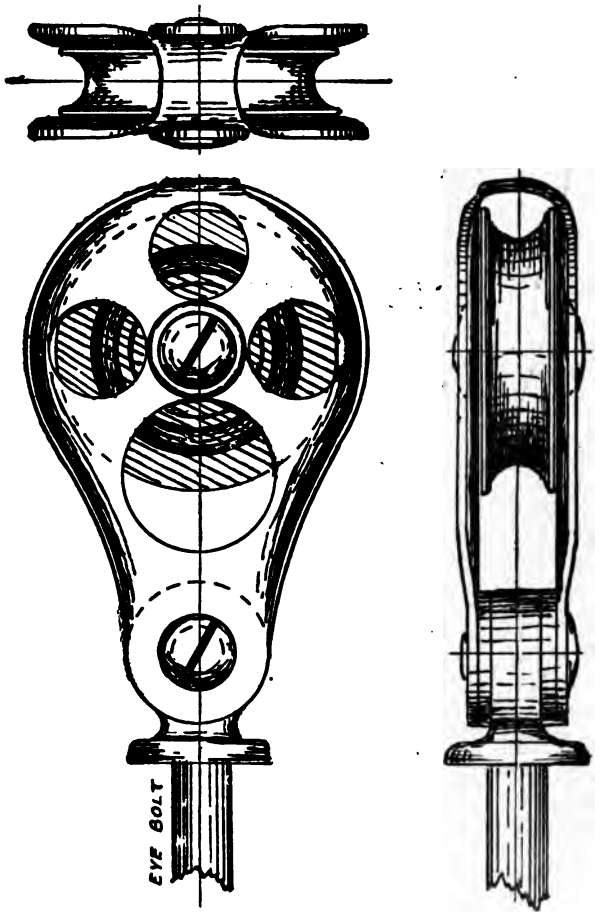
*1 gammon iron and chain sheeve.
1 pair fair leads, right and left on bow.
*1 "Dufferin" winch.
1 Mooring bollard.
*1 bowsprit heel strap.
1 set shroud and runner plates.
*1 pin rail at foot of mast.
1 pair fore sheet fair leads.
1 fore tack lead (No. 1 design).
1 deck plate for fore tack purchase.
1 pair fore sheet cleats (A).
1 pair fore tack cleats (A).
1 pair runner cleats (A).
1 pair spinnaker guy cleats (A).
*1 pair main sheet cleats (B).
*1 pair main sheet lead blocks.
*1 main sheet buffer.
or, 1 main sheet horse.
1 flush deck pump, or semi-rotary pump.
1 binnacle and spirit compass.
1 anchor and chain cable.
1 small anchor and warp.
1 chain pipe on deck.
1 tricolor lamp.

VARIOUS BLOCKS.

Ironwork on Spars.

*1 crantz iron, bobstay, rod and rigging screw on bowsprit.
1 set of rigging screws for shrouds.
1 spinnaker boom gooseneck.
*1 mast band and main boom gooseneck.

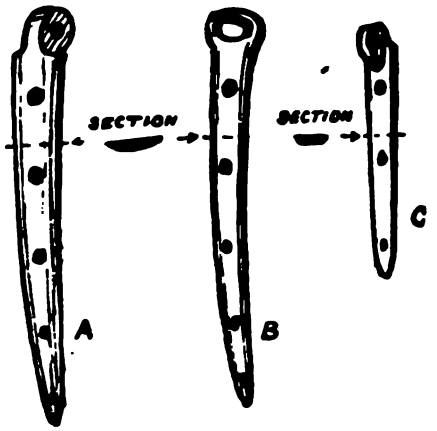
1 pair saddle-jaws for gaff.
*1 main halyard bolt.
*2 peak halyard bolts.
1 set of Turner's reef gear on boom. (*See illustration of reef gears.*)



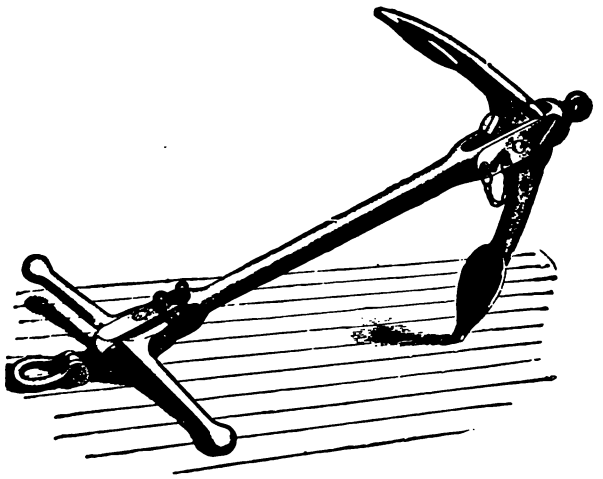
LIGHT SHEET METAL, DECK LEAD BLOCK, PATENTED SHEEVE.

1 set of end fittings for roller headsail. (*See illustration of reef gears.*)

The above list covers all the fittings in general use, but



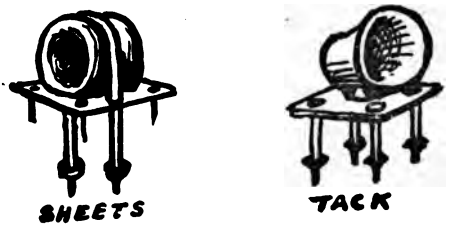
A. B. SHROUD PLATES.
C. DECK PLATE FOR PURCHASE.



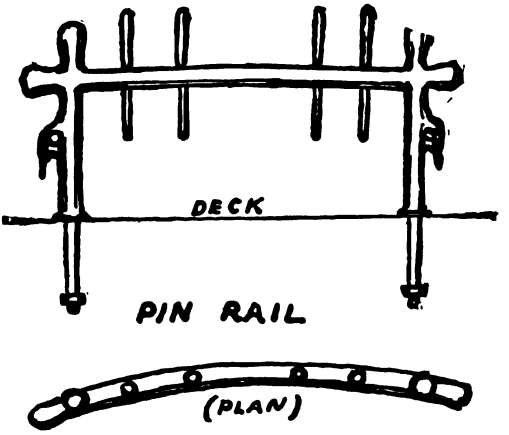
OPEN.

CLOSED.

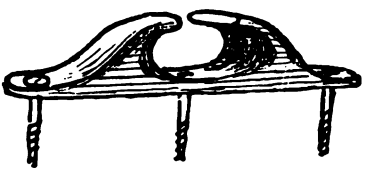
DIRIGO FOLDING ANCHOR.



FAIR LEADS



PIN RAIL



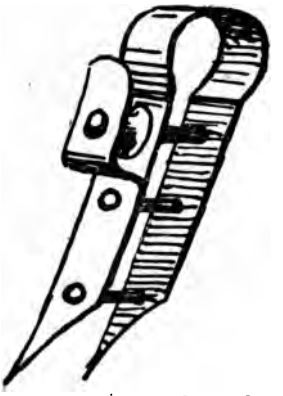
BOW WARP CLEAT
OR FAIR LEAD.

Fittings

everyone has his own fancies, and would be able to get any other fittings he may require, either ready made, if of stock patterns, or made to drawing by the smith. All the fittings illustrated above can be obtained from the yacht fitters.

The following notes may be useful when fixing the deck fittings in place:

The gammon iron must fit the stem well, and the upper bolt should pass through the chain sheeve and top of stem, and be set up with a nut. The other two bolts should be clenched.

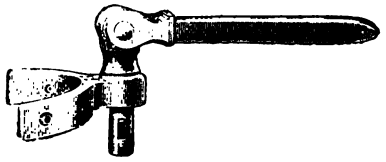


GAMMON IRON & CHAIN SHEEVE

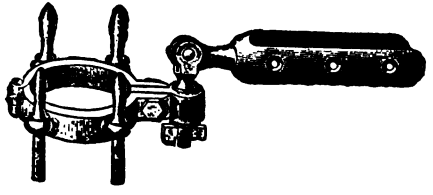
The bowsprit heel strap (or fore tack fair lead, in the case of the smaller boat) should be secured by through bolts and nuts, or with very large screws to a stout beam.

The shroud plates, etc., should have an oaken timber worked inside the planking, between the ordinary timbers, and they should be through bolted at the top, and through fastened with stout copper nails at the bottom.

All fair leads and cleats should be well secured. They may be screwed to beams, or if there is no beam at the proper place, a piece of hard wood should be placed under the deck to take



SPINNAKER BOOM GOOSENECK



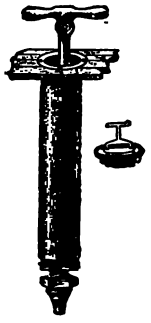
MAST BAND & MAIN BOOM GOOSENECK

RIGGING SCREW

SPIRIT COMPASS & BINACLE

DUFFERIN WINCH

TRICOLOUR LAMP



FLUSH DECK PUMP

MAIN SHEET HORSE

SCREW EYE

MAIN SHEET BUFFER

CHAIN PIPE

SEMI-ROTARY PUMP

BLAKE'S STOWAWAY ANCHOR

SWIVEL SHEET LEADING BLOCK

the screws. If fixed to coamings, they should be through fastened with stout copper nails, or rod, clenched over rings.

Fittings.

The pin rail must either go through the main mast beam, or else have a pair of fore and aft carlines fitted to the beam to take the bolts. This applies to the main sheet horse or buffer, and its leading blocks: also to the winch, or capstan, and any of the deck fittings that have very heavy strains on them.

CHAPTER XIV.

Cabin Fittings for No. 2 Design.

THE most important parts of the interior work are the bulkheads and lining or ceiling, and all this part of the work must be completed before any of the fittings can be put in.

As stated in a previous chapter, this should be done before the deck is on; there will then be more light and room to work than there would be after the boat is decked; but the berths and other fittings are better left till the rest of the work is finished.

Fitting the Bulkheads

All bulkheads should be tongued and grooved, and if they are to be perfectly watertight they should also be lined with painted cotton, which should lap over the skin of the boat, about an inch all around, and be held in place by a wood fillet bent round the angle between bulkhead and skin, and well screwed to both. This method will ensure a perfectly tight bulkhead, which is otherwise very difficult to obtain.

If there is not a timber exactly at the place where the bulkhead is to be fitted, an extra stout timber should be bent round at that point and well screwed to the skin, forming a ledge or fillet to which the planking of the bulkhead may be fastened.

The angle between the under side of the deck and the inside of the shelf and planking is the hardest part to fit, and this should be done at each side first, working from the sides to the center, but taking care that the joints in the planks are vertical, and all the beads on the same side. (V joints and narrow planks look very well in bulkheads and lining, in place of the usual bead.)

For plain work, ordinary $\frac{5}{8}$ in. match boards, if picked clear

of knots, will do very well, but it is very rough, and liable to shrink and go out of shape.

Teak, mahogany, kauri pine and cedar, all make very good bulkheads, the latter being very light, and suitable for racing boats.

The ordinary bulkheads in the cabin and forecastle are not intended to be perfectly watertight, so there is no need to take very much trouble over the fitting of the joints except so far as looks are concerned; but the sides and ends of a watertight cockpit require most careful fitting if leaks are to be avoided, all joints should be well bedded in red and white lead or thick varnish, and either tongued, rabbeted, or fitted with fillets at the back. The main joints between the floor, sides, and ends should be covered with angle beads bedded in thick varnish, and the floors should be covered with linoleum. It is best to fit the sides and ends of the cockpit first and put in the floor afterward; a small drain pipe should be fitted from each of the after-corners of the cockpit floor leading through the planking. If this is of lead, it can easily be fitted tightly into the holes in the cockpit floor and planking, and if a quarter-inch is left projecting at each end it can be turned over with the point of a hammer and screwed or nailed to the wood.

Fitting the Cockpit

The cabin doors should be properly framed exactly like an ordinary house door; except that there will be only one panel in each door, instead of four, and the frame will be of hard wood.

The top and bottom rails of the door have a groove ploughed on their inner edges to take the panel, which is fitted into the groove before the framing is put together. The panel should be about half the thickness of the framing, which ought not to be less than 1¼ in. stuff, of a width suitable to the size of the door. The joints between the stiles and rails of the framing should be mortise and tenon, but a plain halving is much easier to fit, though not nearly such a good job, as it cannot be wedged up after the panel is in, as the others can.

Cabin Doors

Rabbeted door-posts and a sill must be fitted to the bulkhead to form a doorway; the doors should open outward, and shut against a strip of rubber in the rabbet on the posts and sill, thus forming a watertight joint. The central joint between the doors can be made watertight in the same way, but in all cases where rubber is used, it must be carefully looked after, as it soon perishes at sea.

Watertight doors in the cockpit bulkheads are usually fitted without hinges, but with two cleats on the back, shipping inside the doorway. The door is fitted with a rabbet all round it, which overlaps the doorway and is lined with rubber. The cleats on the back of the door are cut slightly tapering so as to draw the door tightly into place when it is closed, and the other end of the door is forced against the bulkhead by means of a cam-shaped button or a thumb screw.

kpit rs

The seats in the cockpit should be fitted to lift up and give access to the side lockers, which are very useful for warps, fenders, etc. The seats must have a ledge running round the inside of the opening, with a groove in it under the joint, to carry off any water which may come through. This water-course is also fitted round skylights and hatchways, etc.

kpit ts

When the bulkheads and doors are finished, the floor should be laid. This is usually of 1 in. spruce or white pine, on 1 in. by $2\frac{1}{2}$ in. bearers, spaced 1 ft. 2 in. apart, and resting on the timbers; it should have the two middle planks made to take up easily for access to the keel; they must be cut at least $\frac{1}{8}$ in. too small all round, or they will swell, and stick when wet. These two planks should be fastened together with ledges, so as to come up in one piece, and two good sized finger holes should be bored, one at each end. The rest of the flooring can be screwed down after it has had a coat of paint on the under side.

kpit or

The whole of the inside of the boat should have been well painted with at least three coats of best oil paint before any inside work was done. The lining or ceiling of the cabin should

be done with 2 in. planks of $\frac{3}{8}$ in. cedar or pine, and the edges of the planks should have a bevel, so as to form a V joint, or else a very small bead worked on the lower edge of each.

There is no need to shape these narrow planks unless the boat is very hard in the bilge, and has a lot of curve in the sides of the cabin. In most cases they can be forced into place easily, and nailed to the inside of the timbers with short copper nails.

Lining the Boat

The lining should be carried down the side just below the level of the sofa berths, which will be fitted over the lining.

A space for ventilation, between the lining and the planking, must always be left at the top. Where the shelf does not come up to the level of the deck, as described previously, there is no occasion for any further ventilation; but if, as in many boats, the shelf is carried right up to the deck, then a space for ventilation must be left. This is done either by piercing holes in the upper plank of the lining, or by keeping a space of $\frac{1}{4}$ in. between it and the under side of the shelf. The former method, if the holes are arranged in ornamental patterns, is the neater.

Ventilation Space

The fronts of the sofa berths can be put in one piece for each side, fastened to cleats screwed to the bulkheads at each end of the cabin, and bent to any required curve, by struts from each other. The lower edges will have to be fitted to the curve of the boat, where a portion of the side shows between them and the sides of the floor, at each end of the cabin. This is done in the same way as described for fitting the edge of a plank, except that in this case the whole board is cut off to the correct length, and bent into its place between the bulkheads and pressed down, till some part of it touches the side of the boat; this will probably be the forward corner. See that the board is level with the floor of the cabin, and bent to its correct curve, if any, and then take spilings along the lower edge from each timber, starting at the point where the board is farthest from a timber; and taking that distance, set off the same distance vertically above each timber on the face of the board. Having set off all the

Fitting the Sofa Berths

spilings, cut the lower edge to them, remembering to bevel the edge to suit the curve of the boat's side as nearly as possible. When the two boards are correctly fitted to the timbers, skew-nail them to each timber, and screw the ends to the cleats on the bulkheads. If the ends are not fitted against the bulkheads, a small frame must be made of two pieces of 1 in. by 2 in. white pine halved together, one of them vertical and securely fastened to a timber, and the other horizontal and also fastened to the same timber. Both parts are on edge, the horizontal piece giving the width of the berth at that point, and the vertical piece giving the height above the floor, and also being a firm stanchion to fasten the front to. These frames will be required about every 2 ft. along each berth, to support the seat, and they may be put in before the fronts are fixed.

ltting the ›fa berths i the Cabin

The seats or locker-tops are usually of 1 in. white pine, and made in short, movable sections, giving easy access to the lockers below the sofa. The portion of the locker-top next the side of the boat must be fitted, or scribed in, in the same way as the lower edges of the fronts, and when fitted should be screwed along the inner edge of this fitted piece, and another inside the front at the level of the cross frames, and with them, forming a support to the movable pieces of the top, all of which should have large finger-holes for lifting.

Teak, mahogany or pitch pine, all make good fronts to the berths, and, if desired, moulding can be fastened with fine nails to the face of the fronts, so as to give the appearance of panels. It should be of some hard wood, giving a good contrast to the wood of the front, and may be about $\frac{1}{2}$ in. in thickness.

The front of the sofa berth is usually left about $1\frac{1}{2}$ in. above the locker-top, to prevent the cushions slipping off, and if false framing and panelling is used, a capping of the same hard wood must be worked over the joint along the top.

Sideboards or cupboards are usually fitted at one or both ends of the berths in larger boats; and these must be framed in

1 in. × 2 in. white pine, before they have the sides and top fitted. Some prefer a door at the front, and shelves inside, while others have a lid only on the top. The former is usually the most convenient, as, if the top has a small ledge or rail round it, it is very useful as a shelf, and the interior being divided with shelves (each with a ledge on the front edge), will hold a lot of small odds and ends of provisions, bottles, etc., all easily get-at-able.

Fitting Sideboards and Cupboards

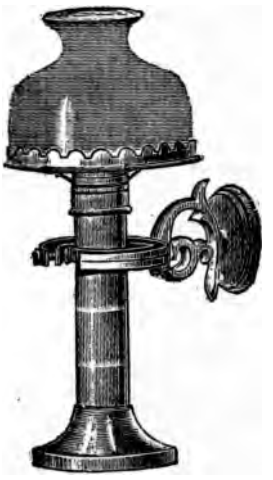


FIG. 47.—SWING CANDLE-LAMP.

The sides of the cupboard should be made in the same way as the bulkheads, and the front must have a doorway, with a framed door on brass hinges.

NOTE.—All hinges and locks must be *entirely of brass.* Many so-called brass locks having steel springs and pins, and the hinges, also, having iron pins, which soon rust.

Any amount of ornament may be put into the mouldings and panelling of the berths and sideboards, etc., and there is always something to do in the winter evenings, after the boat is laid up, in making odds and ends of racks, bookshelves, and other knick-knacks for the cabin. There is no need to go into

detail as to these various small items, except to say that a pair of net racks, like those in railway carriages, are always useful, also a set of bookshelves, while a tin chart case and the binoculars may each have a small rack out of the way.

Cabin fittings

A good eight-day clock and aneroid should always be provided and fixed to the bulkhead. Two or more swing candlesticks will be required (*see Fig.* 47), and, of course, the necessary upholstery and bedding. "Pantasote" or "Pegamoid," stuffed with "Kapok," is about the best form of cushion for

FIG. 48.—STOVE.

yacht cabins, as the cushions are not affected by seawater, and are also life-buoys, while they look like leather, and keep soft.

Galley fittings

The other interior fittings should include a double wickless paraffin stove (*see Fig.* 48), and all the cooking utensils, and plates, etc., should be of the best enamelled ware.

A large fresh water tank should be fitted under the cockpit floor, with a pipe and stop-cock in the cabin, and a filling-pipe and screw plug in the floor of the cockpit. If an ordinary bicycle air pump is fitted in the side of the tank, so that it can be

worked from the cabin, a pressure of air can be maintained in the tank, and water may be drawn off at will, even when the tap is above the level of the top of the tank. All that is required is, that the drawing off pipe should lead from the bottom of the tank, and that all joints should be air-tight, which is easily secured by greasing all the screws well. **Water Tanks**

Proper lockers and racks should be fitted for the plates, knives and forks, etc., and cooking utensils; but, as everyone has his own ideas on these points, they are best left to the owner's fancy.

SPECIFICATION, No. 1.

Specifications No. 1 Design

All material used to be of best quality, and all timber to be sound, free from sap, and well seasoned.

DIMENSIONS.

L. O. A. = 22 ft. 0 in.
L. W. L. = 17 ft. 0 in.
B. = 6 ft. 0 in.
D. (hull) = 0 ft. 8 in.
D. (plate) = 4 ft. 8 in.

SCANTLINGS.

Keel.—American elm, 8 in. sided amidship; 1½ in. moulded; tapered at ends as shown.

Stem.—English oak, natural crook; 4 in. sided at keel, 2¼ in. sided at deck; 2¾ in. moulded.

Stern Knee.—English oak, natural crook; 1½ in. sided; 3 in. moulded at throat; 1 in. moulded at upper end; 1½ in. moulded at rudder case; well fastened to keel and transom.

Transom.—Mahogany, teak, or elm, ¾ in. thick.

ecifications
. 1 Design

Timbers.—American elm, $\frac{5}{8}$ in. moulded, and $\frac{3}{4}$ in. sided; spaced 5 in. center to center. Steamed.

Floor Timbers.—Oak, 1 in. sided, and moulded as follows:

No. 1 (from stem) $1\frac{1}{2}$ in. on top of keel, tapered to $\frac{3}{4}$ in. at ends, arms 1 ft. from centre of keel.

No. 2. Same sizes as No. 1, but with 1 ft. 3 in. arms.

No. 3. $1\frac{1}{4}$ in. sided, and $2\frac{1}{2}$ in. moulded on keel.

No. 4. (Fore end of case, into which it is joggled). $1\frac{1}{4}$ in. sided, and $3\frac{1}{4}$ in. moulded on keel.

No. 5. (2 half floors at side of case.) 1 in. sided, and $3\frac{5}{8}$ in. moulded on keel.

No. 6. (Half floors same as No. 5). 1 in. sided, and $3\frac{7}{8}$ in. moulded on keel.

No. 7. (Half floors same as Nos. 5 and 6). 1 in. sided, and $3\frac{7}{8}$ in. moulded on keel.

No. 8. (Aft end of case, same as No. 4). 1 in. sided, and $3\frac{3}{8}$ in. moulded on keel.

No. 9. 1 in. sided, and $2\frac{1}{2}$ in. moulded on keel.

No. 10. 1 in. sided, and $1\frac{1}{4}$ in. moulded on keel.

No. 11. 1 in. sided and moulded, with 1 ft. in arms, joggled in fore end of rudder case.

NOTE.—Nos. 3 to 10 are all flat on top, and form bearers for the floor boards, so that the length of arms will be regulated by the width of the flooring.

Center Case.—Cedar, pine or mahogany, $\frac{3}{4}$ in. thick, and 1 ft. 10 in. wide. Stanchions at ends 1 in. thick by $1\frac{3}{4}$ in. wide, rabbeted into ends of case. Inside width of case and slot, $\frac{3}{4}$ in. Length of slot, 5 ft. $1\frac{1}{2}$ in. Length of case over all at keel, 5 ft. 6 in. Length of top of case, 5 ft. 4 in. The hole for the bolt is 7 in. aft, from the inside edge of the fore stanchion, and $6\frac{3}{4}$ in. up, from the lower side of the keel.

Sills.—Mahogany, 1 in. thick, and moulded to level of tops of floor timbers and curve of keel; the ends of half-floor timbers are dovetailed into the sills for half their moulded depth.

Case Knees.—One at each end of case on the floor timbers. These are of $\frac{1}{8}$ in. sheet steel, or brass, 8 in. high, and 14 in. across the lower arms; they are made by cutting the sheet metal 1 in. deeper than the finished size of the knee, and bending the extra inch at the bottom at right angles to the rest of the plate, so that it forms a base, resting on the floor of the timber, the end of the case being well screwed to the center of the upright plate of the knee.

A pair of steel knees to be fitted to take the pin or bolt of the center plate. They must be fitted over the sills, and should rest on two false floor timbers, fitted on the bottom of the boat, and level with the top of the keel, so as to form a firm base for the knee to rest on.

The arms of these knees to be 1 ft. long, the upper arms being swelled to take the plate bolt, and screwed to the case and sills, the lower arms being through fastened through false floor and planking. These knees should be 1 in. $\times$ $\frac{3}{8}$ in. at angle, tapering to $\frac{3}{4}$ in. $\times$ $\frac{3}{16}$ in. at end of arms.

Planking.—Cedar, mahogany, teak, kauri pine, or larch, $\frac{1}{2}$ in. thick, not less than 9 planks a side.

Deck.—Cedar, yellow pine, American spruce, or archangel white pine, $\frac{1}{2}$ in. thick, tongued and grooved, and covered with painted cotton.

Inwale or Shelf.—American elm, mahogany, or Oregon pine, $2\frac{1}{2}$ in. $\times$ $1\frac{1}{4}$ in. amidships, tapered at ends, fitted flush with underside of deck.

Beams.—Kauri pine, Oregon pine, oak, or American white wood, $1\frac{3}{4}$ in. moulded $\times$ 1 in. sided, spaced as shown on construction plan.

NOTE.—If oak beams are used, the scantlings may be reduced to $1\frac{1}{2}$ in. $\times$ $\frac{3}{4}$ in.

The main beam at the mast is sawn and steamed to shape, and is of oak $1\frac{1}{4}$ in. moulded $\times$ 5 in. sided.

The beams are only let into the inwales or shelves for half

Specifications No. 1 Design

their depth, with a dovetail one side only; and these dovetails will be cut only half way through the *thickness* of the inwale or shelf, so that the ends of the beams do *not* go right through the inwales or shelves.

Carlines.—Same material as the inwales or shelves, $1\frac{3}{4}$ in. $\times$ $1\frac{3}{4}$ in.

The filling pieces between the fore end of the carlines and the coamings may be of any light, easily worked wood.

Knees.—All hanging and lodging knees, and the breast hook, to be natural oak crooks, $\frac{3}{4}$ in. thick, and of shape shown.

Coamings.—American elm, $\frac{5}{8}$ in. thick, of height and shape shown (add thickness of deck and depth of carline to the heights).

Rudder Case.—Same material as center case, but all scantling to be reduced one-third ($\frac{1}{2}$ in. sides, etc.). All details of fixing similar to center case, except that no knees are used.

Flooring.—White pine or spruce 1 in. thick. Shaped at edges to side of boat, with at least two places for baling, the remainder to be screwed to floor frames.

Seats.—Teak or mahogany, 1 in. thick, as shown.

Center Plate.—Galvanized iron or brass, $\frac{1}{2}$ in. thick to shape shown hung on a $\frac{3}{4}$ in. bolt of same material as the plate; the hole for this bolt is $6\frac{3}{4}$ in. from the two edges of the plate, and the corner of the plate is a quarter circle struck from the center of the hole. All edges exposed below the keel to be sharpened. The plate to be lifted by a wire pendant and tackle from the mast. The wire to be 1 in. circumference, and the tackle to consist of a 3 in. double block, shackled to a plate on the after-end of the case, and a 3 in. treble block spliced into the end of the wire pendant, the wire pendant to reeve through a $3\frac{1}{2}$ in. sheet brass single block at mast.

Rudder.—A steel tube, $1\frac{1}{4}$ in. outside diameter, for the stem split to form a fork on each side of the blade, which is $\frac{1}{8}$ in. steel. Details of head, etc., as shown in previous chapter.

Spars.—Natural grown Norway spars of the lengths shown on sail plan, and diameters in proportions given in the chapters on spars. (Jib roller to be bamboo.)

Specifications No. 1 Design

Sails.—Stout union silk or cotton; to sail plan.

Standing Rigging.—Best plow steel wire rope, $\frac{3}{4}$ in. circumference (1 pair shrouds, 1 forestay and 1 roller wire).

Running Rigging.—Main halyard, best flexible steel wire rope, $\frac{3}{4}$ in. circumference.

Jib tack, best flexible steel wire rope, $\frac{3}{4}$ in. circumference.

Span on gaff or yard, best flexible steel wire rope, $\frac{1}{2}$ in. circumference.

Main sheet, $1\frac{1}{4}$ in. circumference, best cotton rope.

Jib sheet, spinnaker guys, and topping lifts, 1 in. circumference, best yacht manilla.

Main halyard whip, peak halyard, and jib tack whip, $1\frac{1}{4}$ in. circumference, best four-stranded yacht manilla.

Roller line, and clew outhaul on jib, 1 in. cable laid flax line.

Fastenings.—Planking and deck, $1\frac{1}{4}$ in. × 14 gauge, copper nails.

Floor frames and knees, 12 gauge copper nails of suitable length.

Plank scarphs, $\frac{3}{4}$ in. × 16 gauge scarph nails.

Keel scarphs, etc., $\frac{3}{16}$ in. copper rod and stout nails.

Center case, etc., stout brass screws from 4 in to $\frac{3}{4}$ in.

Deck and other Fittings.—As described in previous chapter.

Blocks for No. 1 Design.

Peak Halyard.—1, $2\frac{1}{4}$ in. single, rope strop, patent sheeve, at mast head.

Throat Halyard.—1, $2\frac{1}{2}$ in. single sheet metal block, patent sheeve for wire in mast. 1, $2\frac{1}{2}$ in. single, rope strop, patent sheeve, spliced into lower end of wire halyard.

Specifications No. 1 Design

Topping Lifts.—2, 1 in. check sheeves on mast head, one each side. 1, 2 in. single, rope strop, sized in bight of topping lifts.

Main Sheet.—5, 2¾ in. single, 3 rope strops, and 2 internal bound shackle lugs, all patent sheeves.

Fore Tack.—1, 2½ in. single, rope strop, patent sheeve, spliced in end of wire tack.

Fore Sheet.—1, 2½ in. single, rope strop, on aft end of upper boom. 1¾ in. check sheeve on fore end of lower boom, starboard side.

Forcsail Clew Outhaul.—1, ¾ in. sheeve in aft end of upper boom, as near the end as possible. 1 bull's eye in clew of sail. 1, ¾ in. check sheeve on fore end of upper boom, port side.

Center Plate.—1, 3½ in. single sheet metal block for wire on mast, thwart, patent sheeve. 2, 3 in. double internal bound shackle lugs, patent sheeves.

SPECIFICATIONS.—No. 2 Design.

4-tons T.M. Fast Cruiser of 24 Linear Rating.

Specifications No. 2 Design.

All materials used to be of best quality, and all timber to be sound, free from sap, and well seasoned.

Dimensions.

L.O.A.	31.50	Draught	3.70
L.W.L.	22.50	Sail area	615.00
L.B.P. for tonnage	26.00	Displacement	2.85 tons
Beam extreme	6.00	Weight of lead keel	1.25 "

Scantlings, Etc.

Keel.—Moulded 3 in. amidships, and as shown at scarph; sided 8½ in. amidships.

Stem.—Moulded 2¾ in. at head; sided 2¾ in. at head.

Sternpost.—Moulded at heel 6½ in., and at deck 2¾ in.; sided 1½ in. aft and 2 in. on fore edge.

Specifications No. 2 Design

Counter-frame.—Moulded at inner end 2½ in., and at outer end 2 in.; sided at inner end 5½ in., and at outer end $3\frac{3}{16}$ in.

Deadwood.—Moulded amidships 8½ in.; sided to fit keel and stern-post.

Archboard or Transom.—1 in. thick of shape shown, and steamed or sawn to curve.

Timbers.—1 in. × 1 in.; steamed, spaced 6½ in. centre to centre.

Floors.—Wrought iron; thickness at throat ⅜ in., and $\frac{3}{16}$ in. at ends; width at throat 1 in., and ¾ in. at ends; spaced at the stations shown on construction plan; the arms to run up to the bilge.

Shelf.—2½ in. × 1¼ in., through fastened at each timber.

Stringer.—3 in. × 1 in., through fastened at each timber.

Beams.—Moulded 2 in., and sided 1 in., mainbeams sided 2 in.

Carlines.—Moulded and sided 2 in.; beams and carlines to be dovetailed to each other and into shelf.

Breasthook.—Oak crook, 1¼ in. × 2½ in. at throat, to 1¼ in. × ¾ in. at ends; 9 in. arms.

Knees.—Oak crooks ¾ in. × 2½ in. at throat, to ¾ in. × ¾ in. at ends; 1 pair hanging knees at main beam in wake of mast; 1 pair lodging knees at main beam in wake of mast; 1 pair lodging knees at quarters from shelf to archboard.

Planking.—¾ in. cedar, kauri pine or mahogany; all planking to be through fastened on both sides, at every timber and floor frame; widths not to exceed 6 in., except at garboards; caulked with cotton and stopped.

Deck.—¾ in. kauri pine, or yellow pine, in 2½ in. widths, tapered fore and aft, secret nailed, caulked with cotton, and payed with Jeffrey's marine glue; the covering board and centre plank to be teak.

Specifications No. 2 Design

Cockpit.—$\frac{5}{8}$ in. teak sides and seats with lockers under; $\frac{7}{8}$ in. pine floor; sides and floor to be made watertight, and a drainpipe fitted in floor; the floor bearers to be $1\frac{1}{4}$ in. × 2 in. white pine.

Companion and Hatches.—To be teak carefully fitted and made watertight, all hinges and locks to be entirely of brass.

Cabin Top.—To be $\frac{1}{2}$ in. pine, with $\frac{1}{2}$ in × $\frac{3}{4}$ in. bent timbers instead of beams, spaced as shown; the coamings to be of $\frac{3}{4}$ in. teak; the whole of the arched top to be covered with painted canvas.

Rudder and Trunk.—The rudder to be oak, with a stem of $1\frac{1}{4}$ in. galvanized steel tube, split below trunk to receive the oak mainpiece; a strap joint and heel bearing of gun metal of the usual form; the rudder trunk to be kauri pine 1 in. thick, with a centre piece $1\frac{1}{2}$ in. thick.

Tiller.—Steel, of shape shown, $\frac{3}{4}$ in. square, in section at rudder head, and fitted to it with a square, and a brass rudder capnut, also an engraved deck plate forming a bearing.

Lead Keel.—To be cast to shape shown, and to be fastened with Bull's metal or Tobin bronze bolts at stations shown; the end bolts to be $\frac{5}{8}$ in. diameter, and the others $\frac{3}{4}$ in.; the bolts to pass through keel and wrought iron floors; any excess weight to be sawn off the ends, so as to keep the weight in the same fore and aft position.

Main Cabin.—To be lined with $\frac{3}{8}$ in. pine or cedar, and fitted as shown with two sofa berths with lockers under, and teak fronts; the doors to be framed in teak and fitted with hooks; a teak companion ladder and teak collapsible table to be provided; two swing candles to be fitted; floor of $\frac{3}{4}$ in. white pine, on $1\frac{1}{4}$ in. × 2 in. bearers.

W.C.—To consist of a movable pail with handles, and a fixed seat frame, with lid of teak.

Forecastle.—Entered by hinged door from cabin; floor and lockers to be $\frac{3}{4}$ in. pine.

Galley.—A double stove, with set of cooking utensils.

Deck Fittings.—Binnacle to be fitted at fore end of cockpit, with spirit compass; jib and mainsheet horses, fair leads, etc., at foot of mast, chain pipe, bollards, shroud plates; and all usual ironwork, on deck and on spars, to be fitted and of good quality. All usual sheet leads and cleats to be fitted as required, including a stout iron cable lead, on side of stem as shown, and all necessary eyebolts, etc.; also four gun-metal warp leads, one on each bow and one on each quarter.

Specifications No. 2 Design

Pump.—A brass flush deck-pump and suction pipe, discharging into cockpit.

Tank.—A galvanized iron water tank, to be fitted under floor with filling plug in deck, and brass draw-off pump, or air pump.

Lamps.—A set of side and anchor lamps in brass, with screens, to be fitted.

Ground Tackle.—One 20-lb. Nicholson pattern anchor, galvanized; one 12-lb. Dirigo pattern anchor, galvanized; 20 fathoms $\frac{1}{4}$ in. galvanized close link steel chain (tested) with usual shackles and swivels; one 20 fathom $1\frac{1}{2}$ in. warp of hemp, or manilla.

Spars.—A complete set to the dimensions given, of clean grown Norway spars. with the exception of gaff, roller, topsail yard and jackyard, which are bamboo or hollow spars.

Block.—A complete set of best ash blocks (patent sheaves to halyards and sheets).

Standing Rigging.—Of best yacht manilla, 4 strand, 1 in. $\times$ $1\frac{1}{4}$ in., and $1\frac{1}{2}$ in. in circumference.

Sails.—As shown on sail plan, of stout union silk.

Fastenings.—All fastenings to be copper, yellow metal or brass screws.

Galvanizing.—All ironwork to be well galvanized and of good quality.

Painting.—The whole of the woodwork and spars to re-

Specifications No. 2 Design

ceive four coats of best paint or yacht varnish, and to be properly stopped and rubbed down between each coat. The bottom to be coated with Blake's Algicide, copper color. A gold line, in a hollow moulding, to be worked round the vessel, below the covering board.

Upholstery, Bedding, Etc.—The sofas and backs in the main cabin to be properly upholstered in Pegamoid or Pantasote, and stuffed with Kapok. Two colored blankets, pillows and bolsters, to each berth.

Blocks for No. 2 Design.

Topsail Halyard.—2¼ in. patent sheeve in masthead.

Spinnaker Halyard.—1, 2½ in. single rope strop.

Peak Halyard.—1, 3 in. single sheet metal block, patent sheeve, for wire. 1, 3 in. single rope strop, spliced in end of wire halyard.

Throat Halyard.—1, 3 in. single sheet metal block, patent sheeve for wire. 1, 3 in. single rope strop, spliced in end of wire halyard.

Throat Purchase.—1, 2½ in. double rope strop, spliced in end of manilla whip. 1, 2½ in. single internal bound with shackle lugs and becket.

Topsail Sheet.—1, 1 in. cheek sheeve on gaff end. 1, 2½ in. single rope strop at jaws of gaff.

Topping Lift.—2, 1¼ in. cheek sheeves on mast head, one each side. 1, 2½ in. single rope strop, seized in bight of topping lifts.

Main Sheet.—5, 3 in. singles, patent sheeves, 3 rope strops, and 2 internal bound with shackle lugs.

Foretack.—1 metal bullseye on bowsprit. 1, 3 in. single rope strop, patent sheeve, spliced in end of wire tack. 1, 2½ in. single rope strop, spliced in end of whip.

Fore Sheet.—1, 2½ in. single rope strop, on aft end of

upper boom. 1, 1 in. cheek sheeve on fore end of lower boom, starboard side.

Specifications No. 2 Design

Foresail Clew, Outhaul.—1, 2 in. single rope strop in clew of sail. 1, 1¼ in. sheeve in aft end of upper boom. 1, 1¼ in. sheeve in fore end of upper boom, port side.

Runners.—2 bullseye fair-leads on deck for hauling parts. No blocks required.

PART II.—RIGGING.

CHAPTER I.

Rope, Blocks, Etc., and Fitting Rigging.

ALL rigging should be of the best quality obtainable; and it is very false economy to save a few shillings by using second-rate rope or wire. The latter, especially, should be good, many a spar being lost through the breaking of bad wire.

The best wire rope in the market will only cost a few shillings more for the whole outfit than the commonest rubbish. This difference in quality is especially noticeable in the hard steel wire known as "plough steel," and used for all standing rigging. A good flexible steel rope should be of very fine wire, and be nearly as soft to the touch as hemp rope of the same size; there should be no sharp ends when it is passed through the fingers, and it should be bright and silky, flying back to its original shape immediately on being released after being bent.

Steel Wire

The plough steel should also regain its shape to some extent, but not so much so as the flexible wire, and it should be very much stiffer, and composed of coarser wire.

If the wire bends easily, and stays in the shape to which it has been bent, it is usually iron, or very inferior steel, which is even worse than good iron. Never use copper wire rope for any purpose. It will stretch like india rubber, and then break with very little weight.

Phosphor bronze wire rope is excellent for centre-plate

tackles, as it is not affected by sea water; its strength is about 80 per cent. as compared with flexible steel, and its durability under water is infinitely greater, but unfortunately it is not easily obtainable in small quantities.

All wire rope will last much longer if it is soaked in linseed oil or well varnished, and all splices should be thoroughly varnished and parceled with varnished calico before serving.

Size of Sheave for Wire Halyards

Never take a wire rope over a small sheeve; the diameter of the sheeve for flexible wire should be at least ten times the diameter of the wire, while for plough steel the sheeve should be not less than fifteen times the diameter of the wire; even larger sheeves are better, but are usually made too wide in the score.

Manila Rope

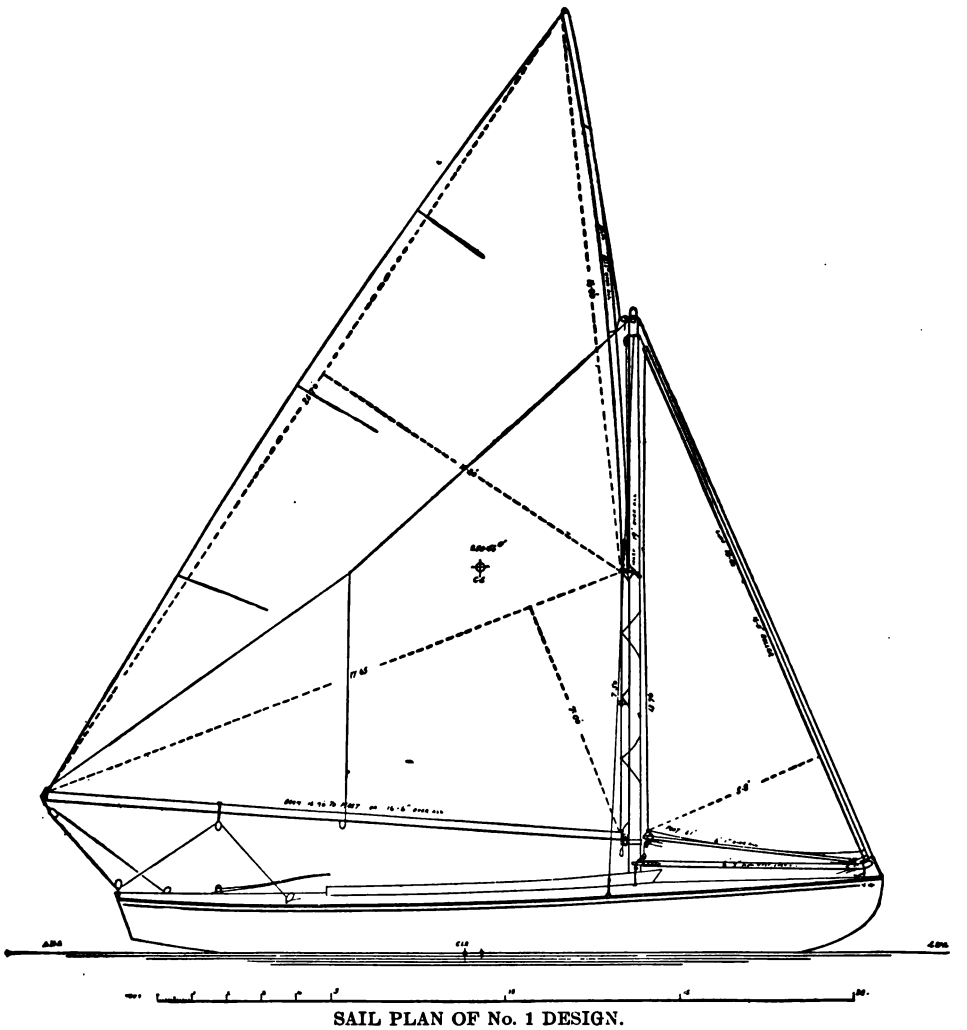
In choosing running rigging, a soft, silky manila should be selected, free from loose fibres and thick places in the strands. It should be a creamy white in color, and have little or no spring in it. Four-stranded rope is usually used for yacht work, as it is smaller in diameter for a given strength, and therefore neater. It is also less liable to kink than three-stranded.

Hemp Rope

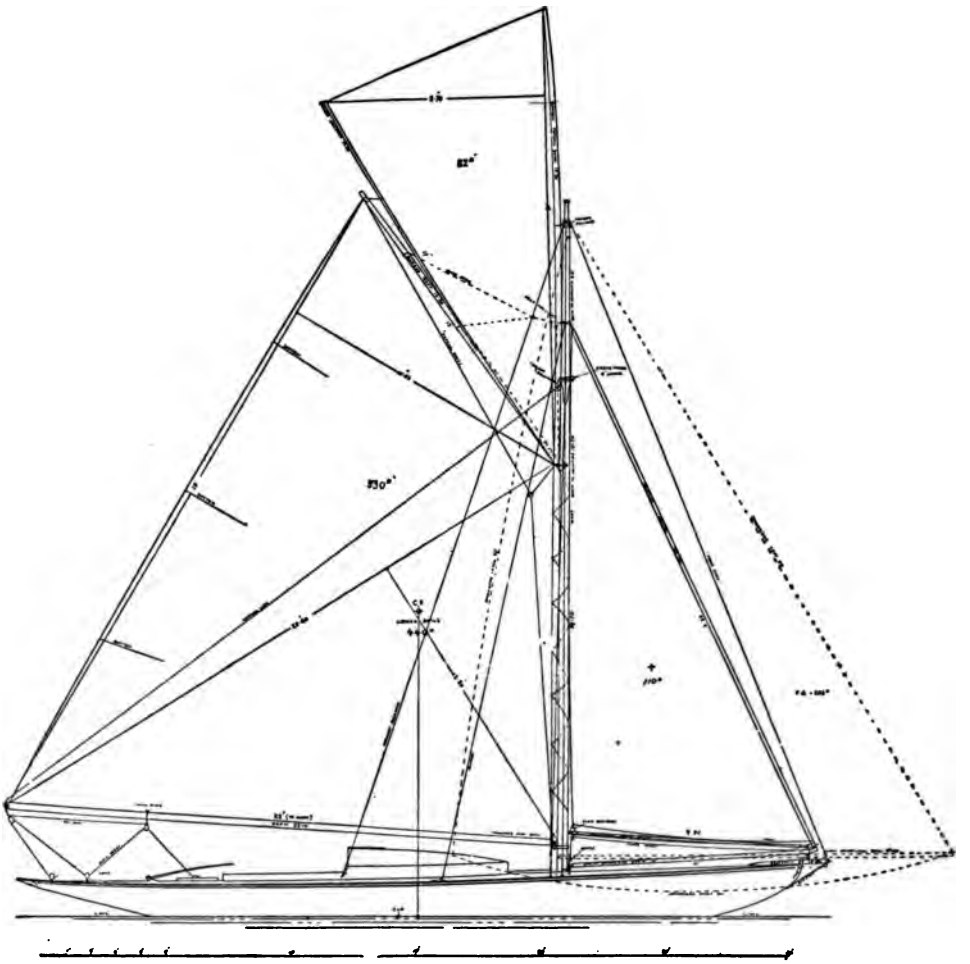
Hemp rope, except for bolt ropes of sails and warps, is seldom used on yachts, as it is very hard, especially when wet. It should be picked with as fine a thread and as smooth as possible.

Cotton Rope

Cotton rope is used a good deal in small boats for sheets, where they are often held in the hand instead of being belayed; it is much softer than manila. Really good cotton rope is very hard to get, most of it being laid up badly, and either kinking when wet or getting too hard. Never get cable-laid cotton, it is very hard, and quite useless for sheets. It may be easily distinguished from the proper hawser-laid rope by the fact that in all cable-laid rope, the strands are each of them a hawser-laid rope, and three of them are laid up together, forming one cable-laid rope. In the hawser-laid rope, used for



SAIL PLAN OF No. 1 DESIGN.



SAIL PLAN OF No. 2 DESIGN.

Rigging

all running rigging, the strands are composed of a number of threads or yarns and not of regularly laid up smaller strands. When splicing cotton or wire, always whip or bind the ends of every strand and also the rope itself at the point where the splice is to commence. This is not so important with either manila or hemp.

On very small boats and sailing canoes a very fine strong line of cable-laid flax is largely used. It does not stretch much, and is about twice as strong as small manila or cotton, but it is 2s. 6d. a pound, while cotton is 1s. 6d., and manila 10d. to 1s.

In addition to the foregoing kinds of rope, a smaller sort of hemp line, called "Houseline," is used for lacing sails, etc., and for serving ropes and splices, a still smaller kind of tarred hemp, called "marline," is required, while "sewing twine," either tarred or waxed, is used for whipping the ends of all the ropes and various other small jobs.

The blocks chiefly used in this country for yacht work are of ash, with internal strops, or bindings, of steel or gun metal. These are suitable for manila, cotton or hemp running gear, but not for wire rope. For this purpose, sheet metal blocks, with large flat sheeves, are the best. These sheet metal

Blocks

blocks are stronger and lighter than the wood blocks, but are a trifle more costly. Blocks of this sort, similar to the illustration, are also suitable for any kind of rope, and if the edges of the shell are slightly turned outward, so as to avoid sharp angles, they will not wear the rope.

All good blocks should be fitted with patent roller sheeves. This is especially important for halyards and sheets, or for any heavy work, as these sheeves reduce the labor to a very considerable extent.

Where internal stopped blocks are unsuitable, as for topsail sheet, throat and peak halyard purchases, etc., ash blocks, with a score for a rope strop, should be used, and before stropping,

the end of the rope should be served where it passed round the block. If a rope strop is required for any purpose, where the block is not spliced direct into the end of a rope, such strops should always be grommets of steel wire rope, well varnished, parceled and served or leathered. **Rigging**

When fitting out a yacht or boat, all the blocks should have the pins withdrawn and greased, and, if a wood block, a little blacklead may be rubbed inside the sheeve holes in the shell.

The leading blocks for the main sheet should have swivels in the strop, so as to turn freely in any direction.

Never use the small cast iron blocks, so often seen on badly fitted boats; they cut the rope and run very badly; also avoid elm or beech blocks, as they are not a good color to start with, and do not clean up well when dirty.

Always choose blocks fully large enough for the rope to be used; nothing is so unseamanlike or so liable to lead to bad accidents as small blocks and big rope. The rope, when rove through the block, should have a clearance in the sheeve hole of at least $\frac{1}{4}$ of its diameter, when dry; that is to say, a rope of $\frac{1}{4}$ in. diameter should have $\frac{5}{16}$ in. sheeve holes in the block. Do not forget, when arranging the blocks for a purchase, that the hauling part should, if possible, be from the traveling block, and not from the standing block. Thus, if two single blocks are used, and the hauling part is from the fixed block, then the power is only doubled. But if the hauling part is from the traveling block, the power is trebled (minus the friction of the block, etc.). **Choosing Blocks**

The rigging of No. 1 boat will be fitted as follows, and will be suitable for any small boat if the sizes of the ropes and blocks, etc., are kept in proportion.

Standing Rigging.—1 plough steel shroud a side, and a forestay, each with separate eyes over masthead, resting on hounds and bolsters, with a manila grommet under the eyes of the rigging. All of these may be set up either with rigging

screws, steel wire, or hemp lanyards. All eyes, etc., should be well varnished and served with yacht marline.

The method of fitting the roller wire will be described in the chapter on roller headsails and reef gears.

Running Rigging.—The main or throat halyard will be a flexible steel wire rope running through a sheet metal block, or sheeve in the mast. One end is shackled to the jaws of the gaff, and the other end has a single wood rope-strop block spliced into it. Through this block is rove a manila whip, with the standing part fast to the mast thwart, or, if more purchase is desired, this end can be rove through a cheek sheeve at the heel of the mast, and led forward to a purchase under the deck consisting of a pair of 2 in. single blocks, one of which may be shackled to an eye in the keel.

The Peak Halyard is a single part of manila, rove through a single wood rope-strop block at the mast-head, and shackled on to the wire span on the gaff. The peak halyard block should be stropped with a thimble, in which is another thimble stropped round the mast-head, so as to allow free play in all directions to the block. The strop round the mast should be placed under the eye of the forestay, or it may be pulled off the mast-head by the sail if it is at all loose.

The Topping Lifts are shackled to the revolving plate on the boom end, and are one piece of rope, being rove through a pair of cheek sheeves on the mast-head, so as to leave a bight on the fore side of the mast. A single block is seized in the centre of this bight, and a whip is rove through it. A light span is attached to each topping lift, so as to hang loose under the boom at about its centre; the use of this being to catch the sail when lowered. Two or more of these spans may be used if desired.

The Main-sheet is double-ended, that is to say, it can be hauled on either or both ends. The chief advantage of this form of sheet is that when one end only is hauled on, the

whole of the purchase of four single blocks is used; but if it is to be got in quickly, as in a gibe, then if both ends are hauled in at once, there is only half the purchase and twice the speed. Rigging

The two blocks shackled to the boom are fast to the claw ring, and to the revolving plate on the boom end, and one of the three blocks on deck is on a horse being stropped to a round thimble traveling on it, while the other two are stropped in a similar manner to eye-bolts on the deck.

These eye-bolts should always be in a line drawn from the centre of the mast through the ends of the horse.

The sketches show various methods of reeving main sheets in small raters. (*See Fig.* 49.)

The Fore-tack (if a roller foresail is used, as shown on both sail plans) is a single wire, rove through a gun metal fair-lead or bullseye on the deck close to the stemhead, its outer end having an eye spliced in it, and the wire being passed round the fore end of the lower boom and through its own eye, then aft through the bullseye, and having a single block spliced in the after end; care being taken that the wire is long enough to allow the boom to be squared right off, when the foresail is used as a spinnaker. A manila whip is rove through the block with the standing part fast to an eye-bolt or deck plate, except in the case of very small boats and canoes, where the tack is merely a single part of manila or flax, without any whip or purchase.

The Fore-sheet is arranged to tend itself in going about, and to do this, a second upper boom is used, as shown; also a horse for the end of the sheet to travel on. By means of the clew outhaul, from the clew of the sail to the after end of this upper boom, the sail can not only be rolled up in the ordinary manner, but the sheet lead can be perfectly adjusted, so as to get exactly the right proportion of strain on the leach and foot of the sail. (*See Fig.* 50.)

The sheet is spliced round a thimble traveling on the horse,

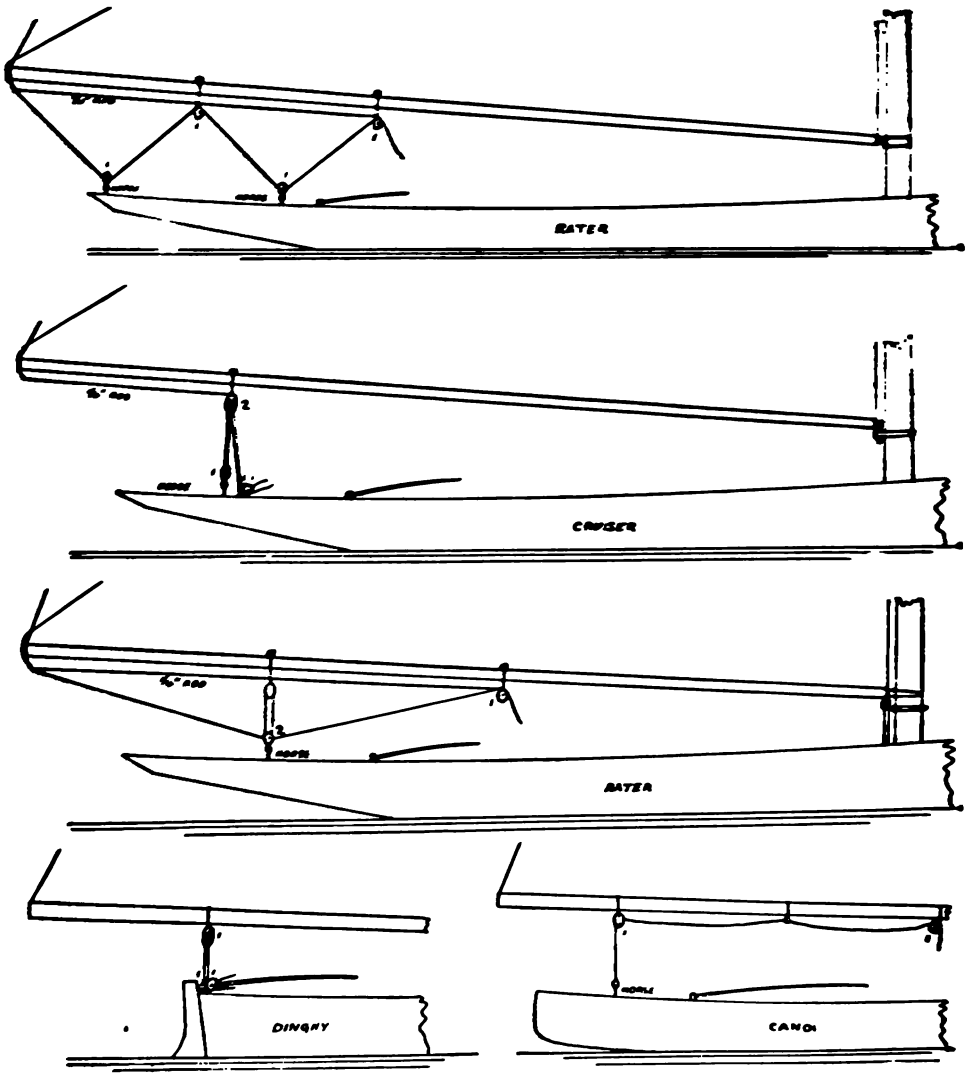


FIG. 49.—VARIOUS ARRANGEMENTS OF MAINSHEETS.

and is then rove forward through the single block on the upper boom, and down and aft through a cheek sheeve on the fore end of the lower boom, and aft to the cockpit. Rigging

The clew outhaul is spliced to a ring traveling along the upper boom, and rove aft through a bullseye, or block, on the clew of the sail; then down through a sheeve in the bare end of the upper boom; forward and down through another cheek sheeve in either the upper or lower boom (but on the opposite side to the sheet lead), and aft to the cockpit, like the sheet.

The Roller Line is fast to the drum of the roller, and led aft through a screw eye, or thimble, seized on the lower boom near, or on, the goose-neck of the upper boom.

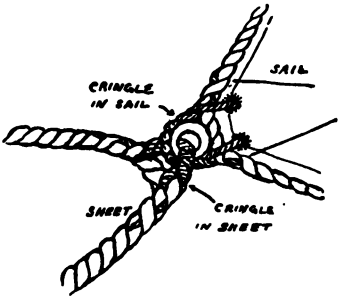


FIG. 50.—METHOD OF ATTACHING FORESHEET.

The Spinnaker Guys are endless, being fast to the fore end of the lower boom, where the wire tack is made fast; then passing aft outside the shrouds and through two small eyes in the deck, one at each after corner of the coamings, returning to the end of the boom on the other side in the same manner. By this arrangement, when the fore tack is let go, and the sail hauled round as a spinnaker, the guy overhauls itself and leaves enough slack to belay on a jamb cleat on deck, but at once becomes taut when the boom is amidships and the tack hauled down again.

A light pair of signal halyards should be rove through a

Rigging

small screw-eye in the top of the mast-head, or through a truck, but the latter is very clumsy on a small boat with a stump mast-head. These signal halyards are very useful for hauling the cover up the roller foresail, as it is laced or hooked on; as by this means a roller foresail can be kept clean and dry, as easily as any other sail.

The Centre-plate is lifted by means of a wire, fast to the arm of the plate, and rove through a large metal block on the mast-thwart, and spliced round a treble block, to which the standing part of the tackle is made fast, the other treble block being shackled to a deck-plate or eye-bolt on the after end of the centre case, a manila fall being rove through the two.

The chief differences between the rigging of No. 2 boat and that of No. 1 are that there are several extra parts, consequent on the greater strain and the extra sails of the larger boat. They are as follows:

Standing Rigging.—1 shroud a side from the hounds and 1 shroud a side from the mast-head, through the arms of the cross-trees. These are set up with rigging screws to two separate shroud plates each side.

One runner a side, from the four-eyed band, to which the peak halyard block and the roller foresail are attached. These runners are cut to reach within an inch of the runner-plate, and the end is shackled to a horizontal wire rope, stretched tightly between the runner-plate and the after shroud-plate; so that the shackle will travel freely fore and aft along the wire, but will not come right up to the runner-plate. A small manila line spliced to the end of the runner, and led through a bullseye on the runner-plate, serves to haul the runner aft, and consequently tightens it to any required tension, with very little effort. The sketch fully explains the method of fitting. (*See Fig.* 51.)

A topmast backstay should also be used for racing purposes, and would consist of a light steel wire, cut to exactly

reach the lower end of the runner, when the latter is hauled aft. One of Blake's patent hooks is spliced into the end of the wire, also a manila line similar to that on the runner, but of smaller size. Rigging

The backstay is kept hooked into the eye of the runner when not in use, and is slacked off with it by the one action; when, however, the backstay is required, it is unhooked from the runner, and the manila line belayed on a strong cleat on the side of the coamings as shown on the sail plan. This method is only suitable for a small craft like the 24 linear rater; as, on

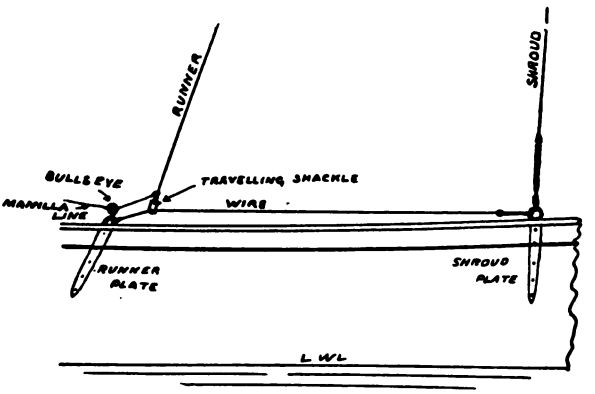


FIG. 51.

a larger boat, sufficient strain could not be put on the backstay to set it up; in this case, there would be a small snatch block on the backstay, and, after taking the line under the cleat, it would be taken over the snatch block and brought back to the cleat again and set up.

For cruising purposes these backstays will not be required, as the large spinnaker and topsail would not be in use, except in very fine weather.

Mast-head.—The fittings of the mast-head will, in addition to the hounds and bolsters used in No. 1 boat, consist of

the following: A pair of American elm cross-trees, 4 ft. wide and 1½ in. × 1 in. in section at the centre.

Rigging

A four-eyed mast band resting on a $\frac{3}{16}$ in. shoulder at the point shown, and with a rivet through the mast-head; this band carries the peak halyard block, runners, and the roller foresail.

There is a large sheeve at the mast-head for the topsail halyards, also a small single block for the spinnaker halyards; above this is the short pole and truck.

A slightly different method of fitting the mast-head gear was shown in the chapter on spars, and either of these may be used; the sail plan shows the neater of the two perhaps.

Gaff.—This is slung at quite a different angle to that of the smaller boat, and has a cheek sheeve for the topsail sheet; the peak halyards are of wire, similar to the throat halyards, and both of these are fitted as for the smaller boat.

The only other differences between the gear of the two boats are that the larger boat is fitted with a bowsprit, and this has a short steel rod as a bobstay, set up to the bowsprit end, with a rigging screw, which is shackled to a small two-eyed band on the bowsprit end, to which the forestay is also set up.

The foretack is led through a gun-metal bullseye stropped to the bowsprit with a stout wire grommet.

The spinnaker and topsail entail some extra running gear, but that for the topsail is apparent in the sail plan, and consists of a halyard, sheet and tack, all of manila and all single ropes. The tack should always be belayed on the opposite side of the mast to that on which the sail is set, so as to keep the heel of the topsail yard close to the mast. The halyard and sheet are bent to the yards with a rolling hitch.

The spinnaker gear consists of a halyard, guy and sheet; the latter being a short piece of small manila spliced into the clew of the sail and made fast to the lee rigging. The halyard is a single manila rope with a large spring hook spliced into

either end, and cut to such a length that the hooks just reach the shroud-plates each side, and are hooked into them when not in use. Rigging

The guy also has a spring hook in the end, which is hooked into an eye in the end of the long spinnaker boom, and into the tack of the sail.

In case ordinary foresheets are preferred to the automatic arrangement I have shown on the sail plans, they should be either shackled into the clew of the sail with a jib-sheet shackle (as illustrated among the fittings), or they may be attached direct to the sail; the best method of doing this is to work a cringle in the centre of the sheets, through the clew cringle of the sail, and made in exactly the same way, from a strand of the same sized rope used for the sheets, which should be of cotton.

CHAPTER II.

Bending and Setting Sails.

THE art of bending sails and stretching them properly is very little known among amateurs, and can be only thoroughly acquired after many years' experience. Even among professional yacht skippers, there are some who cannot stretch a sail properly.

Most sails are spoilt by hauling out the head and foot too tight on the spars. A new sail should only be hauled out on the spars till the bolt rope is "hand" tight, and when it is laced it should be slack enough to just admit one's finger between the spars and bolt rope. More strain can be put on the luff of the sail than on the head or foot, as the roping is stouter, and in most modern racing sails it is of wire, so there is no fear of overstretching it.

Bending Sails

To bend a Gaff Mainsail.—Shackle the throat cringle to the jaws of the gaff, or if the sail is very high-peaked, like a gunter lug, seize the cringle to the jaws with a little drift, so as to allow a small amount of vertical movement when the gaff is well up and down the mast.

Reeve the peak lacing through the hole in the end of the gaff, and haul out gently, as described above; pass about four turns through the lacing hole and peak cringle, and as many more round the gaff, finishing off with two half hitches round the lot. All the lacings must be spliced, either directly into the cringles on the sail, or else have an eye-splice in one end, and be rove through the cringle and their own eyes. This latter method enables the lacing to be easily detached from the sail without cutting the splice.

The head of the sail has now to be laced to the yard, and the lacing must be made fast, as above, to the *throat cringle,* and not to the first lacing eyelet, as is usually done. The object of this departure from the old custom is that if the lacing is made fast to the first eyelet, it is always tending to drag that portion of the sail round the spar; whereas, if it is fast to the cringle itself, the strain on all the lacing eyes is equal. This should be especially borne in mind in reeving a luff lacing round a mast. The head lacing should have a marline hitch at each turn.

Seize the tack cringle with wire to the eye on the reef gear, at the fore end of the boom, and get it down as close as possible, or it will not roll up well. Reeve the clew lacing through the reef gear eye, on the after end, and haul the foot of the sail out in the same way as the head was done, but passing the turns of the lacing round the boom backwards and forwards instead of round and round; the object of this is to prevent the sail from twisting round the boom when rolled up in reefing. This is also prevented by a small groove in the upper side of the boom for the bolt rope to lie in, and also by the way in which the foot lacing is passed. On sails without roller reef gear, it is usual to pass the foot lacing simply round and round the boom through the lacing eyelets, without the marline hitch used on the head lacing; but for a roller sail, the lacing is passed through the first eyelet, round the boom, back through *the same eyelet*, and along the foot of the sail to the next eyelet, repeating this for the whole distance; the result being a round turn at each eyelet, and the lacing passing along the sail from eyelet to eyelet without going round the boom, but being alternately on each side of the sail, and preventing it from twisting on the spar.

Reefing a Mainsail

When the head and foot of the sail are bent to the spar, the sail should be slowly hoisted and the luff lacing rove; or, if mast hoops are used, they should be bent on. There are

two methods of reeving a luff lacing, the first being simply round the mast and through each eyelet, and the other being round the mast and through the first eyelet, and back round the mast, *on the same side*, to the second eyelet, etc., thus keeping the lacing from eyelet to eyelet, on the fore side of the mast, and never taking the lacing round the spar at all. This form of lacing undoubtedly travels better on the mast, but it is liable to pull the luff of the sail alternately to port and starboard at each eyelet.

Bending a Roller Foresail

A roller foresail is bent to the roller by first hauling the luff *tightly* along the roller, and then sewing the two strips of canvas on the luff, *as closely as possible* round the roller; this sewing cannot be too tight.

There are two other methods of attaching the sail to the roller, but they are neither of them so good as sewing.

One way is to have the sail roped like an ordinary sail, and bend it on the roller, seizing it at each eyelet; this is the worst possible method, as the sail is likely to get slack between the seizings, and to slip round the roller.

The third plan is to slip the luff of the sail between the two halves of a wooden roller, and screw it tightly together on the sail; also a bad method.

Bending a Lugsail

A gunter lug, or any other form of lug, is bent to the yard and boom, in just the same way as the gaff sail, except that instead of lacing the head to the yard, in the case of a balance lug, it should be seized to it at each eyelet with small pieces of marline, called "nettles;" then if one is chafed through between the yard and the mast, the others will not be affected, and the sail will still set all right; but if a sail of this sort is merely laced to the yard, and the lacing chafes asunder, the whole head of the sail comes adrift at once, and is useless.

Bending a Topsail

A topsail is bent in this way to both yard and jackyard, but in this case, the stops are used to save time in bending and unbending the sail, as in all large yachts the sail is unbent

every time it is stowed after use. Such a topsail as that of the No. 2 boat need not be unbent every time; the spars, being bamboo, are very light, and it is merely rolled round them and stowed away in the cabin; one end being right up in the bows of the boat and the sail triced up close under the deck at one side, so that it is quite out of the way.

Setting Sails

To set a Gaff Mainsail (No. 2 type).—Haul on both halyards equally, so that the gaff goes up more or less horizontal, till the throat halyard is right up; belay the peak, and set up the throat as taut as possible with the purchase. Then get the peak up till a few small wrinkles show from peak to tack, mostly at the throat; do not overdo this, especially with a new sail.

To set a Roller Foresail.—Let the roller line run out steadily, hauling the sheet aft till the sail is unrolled; be sure and keep a light strain on the *roller line* when *unrolling,* and on the *sheet* when *rolling up,* and keep the sheets quite slack when the sail is rolled up and not in use. By attending to these rules, a roller head-sail should never give trouble.

To set a high-peaked Gaff Sail, like No. 1.—Hoist the sail with the *peak halyard,* till it is up as far as it will go, then haul away on the throat, or main-halyard, till the sail is up, and set up on the main purchase till the luff is as taut as possible. If there are any wrinkles at the jaws, slack off a little of the peak halyard, till the sail sets fairly all over; if the peak of either type of sail is not up enough, the sail will be tight from the jaws to the end of the boom, and is quite useless.

To set any form of Lug.—Shackle on the tack and halyard, then hoist the sail as high as it will go, with the halyard, and set up on the main or tack purchase, till the luff is taut.

To set a Club Jackyard Topsail.—Bend the halyard on the yard with a rolling hitch and the sheet on the jackyard in the same way, taking great care to get them both exactly in the right places.

Hoist the sail chock up into the sheeve-hole and belay the halyard, take the tack line round the fore side of the mast and belay on the opposite side to the sail, getting it as taut as possible. Take a pull on the peak halyards till the gaff is peaked up a bit higher than it should be; then sheet home the topsail as hard as you can and belay, slacking up the peak again to its normal position.

To set a Spinnaker with a Jaw Boom.—Unhook the spring hook of the halyard off the weather shroud, and hook it into the head cringle of the spinnaker; take the guy outside the shroud and runner on the weather side, and hook the spring hook into the eye on the end of the spinnaker boom, and the tack cringle of the sail. Haul the sail chock up with the halyard and belay, make the end of the sheet fast to the mast, and run the boom forward till the jaws can be shipped on the mast well up from the deck, then square away on the guy and the sail is set.

To set a Jib.—Hook the tack on the hook of the bowsprit traveler and haul out; hook the halyard on the head of the sail and the sheets on the clew; then set the halyard up as taut as possible and sheet home.

To stow a Mainsail.—Lower away on the halyards till the gaff or yard is resting on the boom; take the leach of the sail as far forward as it will go, and roll the bunt, or body, of the sail up till it stows snugly. Before lowering, get the sail tyers ready along the boom. With a racing sail it is best not to take the leach forward, but to stow the sail as it falls on the boom, but it does not make such a neat stow. See the boom is firmly in the crutch. In covering the sail, unhook the halyards and lace the cover round the mast; then haul the cover aft and lace it, or hook it, under the boom, hooking the peak halyards to a canvas band passed round the stowed sail, and set up hand taut.

CHAPTER III.

VARIOUS RIGS.

AMONG the various types now in use on small yachts and boats the most popular rig, for either racing or cruising, is the sloop, whether it is of the simple two-sailed type, as shown in No. 1 sail plan, or the more elaborate arrangement with jackyard topsail and large spinnaker carried by the racing cruiser No. 2.

Other nearly allied varieties of the No. 1 type of sloop are the so-called gunter lugs and Solent or Clyde lugs, in place of the high-peaked gaff sail of No. 1. (*See Fig.* 52.) All these three are very much alike, and have been developed from the old standing lug still used by the fishermen. This development has always been in the direction of high-peaked sails, with smaller and smaller proportions of the sail forward of the mast, the "Clyde" lug having only a very small piece of the sail forward, while its next stage, the "Solent" lug, has only the heel of the yard alongside the mast, and nothing forward of it. This heel of the yard is hauled round the after-side of the mast every time the boat goes about, so that it is always to leeward, and to do away with this the heel of the yard was fitted with jaws, to keep it on the after-part of the mast, and alike on both tacks, the result being a combination of the old sliding gunter and the "Solent" lug, generally known as a "gunter" lug. This sail is a great improvement on the "Solent" lug, but has one fault, and that is, that the jaws occasionally get round to one side of the mast and stop there.

Rigs

To get rid of this very annoying habit, various plans have

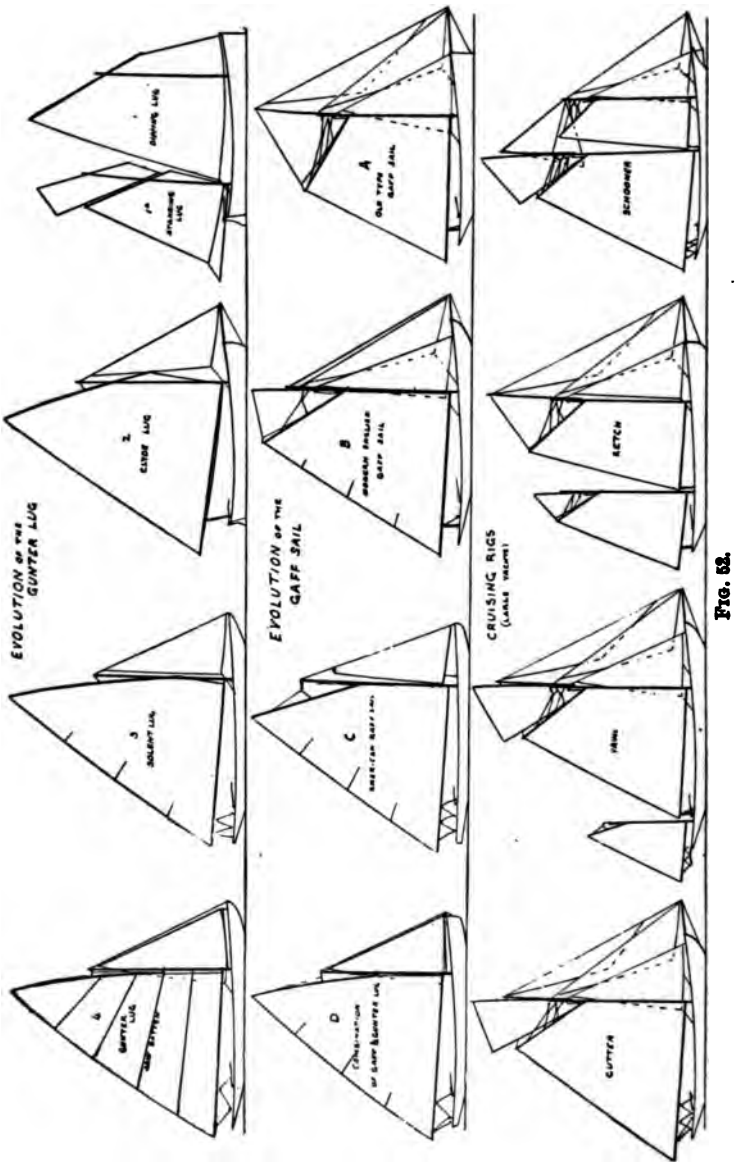

EVOLUTION OF THE GUNTER LUG
EVOLUTION OF THE GAFF SAIL
CRUISING RIGS
A
B
C
D
SCHOONER
KETCH
YAWL
CUTTER

FIG. 62.

been tried, and among them the most successful is to sling the yard by a long wire span, fastened to the jaws, and to the usual place for slinging the yard, with a shackle spliced into it at a point which will allow the yard to sag away from the mast at the slings, for some few inches more than its proper position for setting the sail; the yard being drawn into the mast to the correct place, by a parral line from the slings of the yard. This method answers admirably, especially if long

Rigs

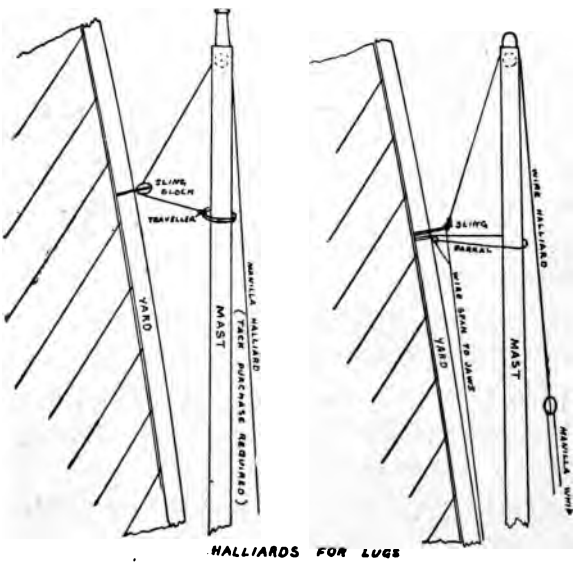


FIG. 53.

battens are used, attached to the jaws as shown in the sketch (*see Fig.* 53), but as it requires two lines, viz., the halyard and the parral, it is now considered better to use two separate halyards, for throat and peak, which practically converts the sail into a true gaff sail, though it still has the same shape as before. The peak halyard is shackled to a long, tight, wire span on the gaff, and in reefing, only the throat halyard is eased up, the peak halyard traveling up the wire on the gaff and always keeping the gaff at its proper angle with the mast. The throat hal-

yard should be rove through a block as close to the jaws of the gaff as possible to keep them from twisting round the mast; they will take the whole strain of setting the sail, the peak halyards merely holding the gaff into the mast.

There have been many heated arguments among experts as to the respective merits of gaff *versus* lug or gunter lug, and the partisans of the gaff have increased the angle of the peak, till the two sails are now identical, except in the halyard arrangements just mentioned. The high peaked sail with rounded head in No. 1 design, has proved far superior to either "Solent-lug" or ordinary gaff-sail, and the moment the gaff is allowed to sag away from the mast to an angle of more than about 10° between mast and gaff, the efficiency decreases, and the boat will not point so close to the wind, while if the gaff or yard is brought close to the mast, as in the true sliding gunter, the boat will point very high, but has lost a good deal of life and will not go through the water so fast. This is the more extraordinary, as the "Bermuda" sail with no yard at all, would seem to be the logical development of the high peaked lug, but it has been well tried by the writer and others, and proved to be inferior to any of the forms of sail previously mentioned.

The only objection to these high-peaked gaff sails is that the whole of the sail area must be carried in two sails, and for cruising purposes this is very inconvenient, on account of the long and heavy spars required to set enough sail to drive the boat at a fair pace in fine weather. For this reason an ordinary gaff sail, as in No. 2 design, is preferable in a larger boat, because it admits of a snug working sail plan, which can easily be increased by means of a topsail and large spinnaker when required. On the other hand, it is not quite so close-winded as the No. 1 sail, and with the extra sails, etc., entails a lot more gear.

Among the other rigs in general use the cutter is most pop-

ular for racing and cruising in yachts of over 8 tons T.M., the single headsail of the sloop being too unwieldy in anything over this size. The cutter is practically the same in every way as No. 2 sail plan, except that she carries two headsails instead of one, and the outer sail is set flying, while the sloop's single head sail is set on a stay. Rigs

As the vessel increases in size the pole mast of No. 2 would give place to a topmast, and the whole of the gear would be more complicated, but, as these details do not apply to small yachts, there is no occasion to go farther into the matter.

A yawl is merely a cutter, or sloop, with a short boom, and

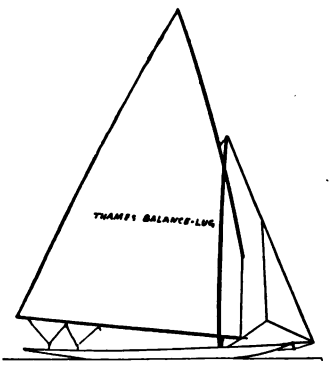


FIG. 54.

a mizzen mast stepped aft of the rudder head. This is a very popular cruising rig, as it reduces the size of the working sails, and enables the boat to be handled under a mizzen and headsail only. Whether this compensates for the trouble of setting and taking in another sail, and looking after this extra gear, is really a question for individual taste to decide, but there is no doubt that a yawl is often inferior to a cutter to windward.

The yawl may have any of the foregoing types of sails, and either one or two headsails, topmast, etc., according to size and the owner's fancy. The size of the mizzen may also in-

crease in proportion to the other sails, to reduce the labor of working a big mainsail, till, by stepping the mizzen mast forward of the rudder, the rig becomes a ketch. This is considered an ideal rig for cruising by some people, but it is less efficient to windward than the yawl, and is very ugly; its only advantage over the yawl being a further reduction in size of the mainsail and increased efficiency when sailing under mizzen and headsails only.

This may be carried to a still further extreme by making the vessel into a schooner, which is little less efficient to windward and much smarter looking than the ketch. A schooner is

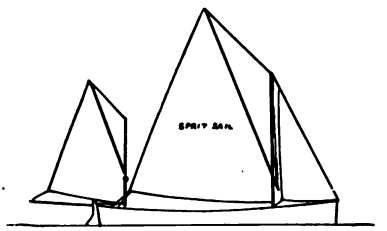


FIG. 55.

undoubtedly the best rig for a large sea-going yacht, but is quite out of place in small craft.

Other rigs used on small boats are the balance-lug (*see Fig.* 54), largely used on the upper Thames raters; the sprit sail (*see Fig.* 55), used on watermen's boats on the lower Thames and many other parts, and the dipping lug, used on the large fishing luggers all round the coast and on ships' boats.

The balance-lug is a very flat-sitting sail with simple gear, but is pressing and requires strong and heavy spars.

The sprit sail is only useful for boats going alongside other vessels, etc., when the sprit can be removed, leaving nothing to get foul aloft; it is a bad sail to windward and very pressing.

The dipping-lug is the most lifting sail known, and the gear is simple, but it requires a large and expert crew to work it.

CHAPTER IV.

Reef Gears.

ROLLER reef gears, of various sorts, are now in general use in small yachts, whether used for racing or cruising; batten reefing has been in use in canoes and very small raters for many years, but is now being rapidly superseded by roller gear, even in the smallest sizes; therefore we need not go into details, as these forms of reefing have been fully described in the canoeing books.

The roller boom gears now in use may be divided into three classes:

1. Hand rolling: the boom being merely turned by hand and locked in the desired position by a key on the gooseneck shank, when the boom is pressed forward by the strain on the sail. The key being disengaged, by pulling the boom about an inch aft from the mast, before rolling. This gear is in use on the Bembridge Club boats, and is no doubt the simplest form; but is not very easy to work, and it is very slow. **Roller Reefs**

2. The Ratchet gears: in which the boom is turned by means of a ratchet winch and lever, on the end of the boom. This form appears to have been first introduced on yachts, by Mr. F. D. Marshall on the 7-ton cutter *Lady Nancy,* and has been fully illustrated in Dixon Kemp's Yacht and Boat Sailing. Turner's gear is of course the best known of this type in England, but an improved ratchet gear has just been brought out by Max Oertz, the well-known Hamburg yacht designer. It is the best gear of this kind both in design and workmanship.

3. Drum and line gears: similar in principle to the ordinary roller head-sails. The simplest form of this gear is a

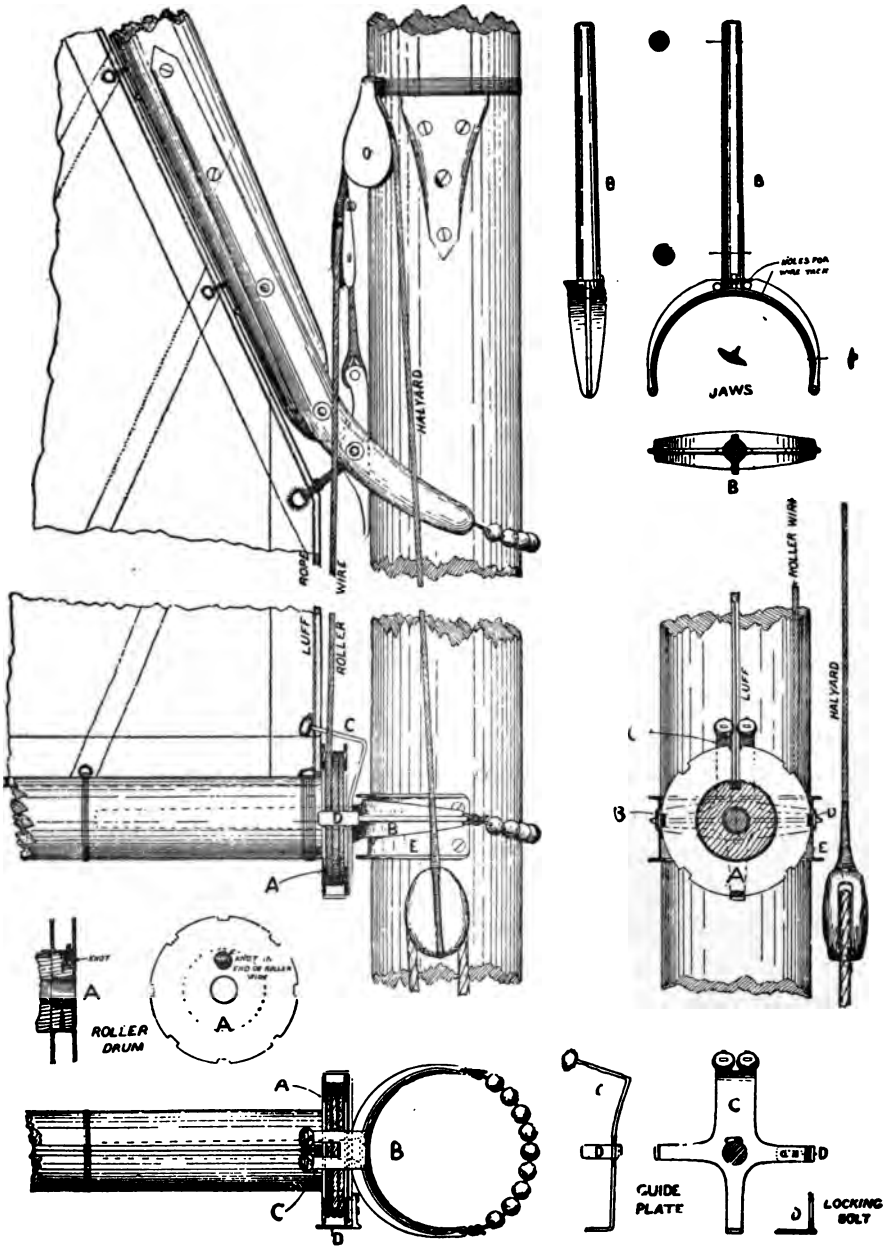


FIG. 56.—HOPE'S REEF GEAR (SMALLEST SIZE).

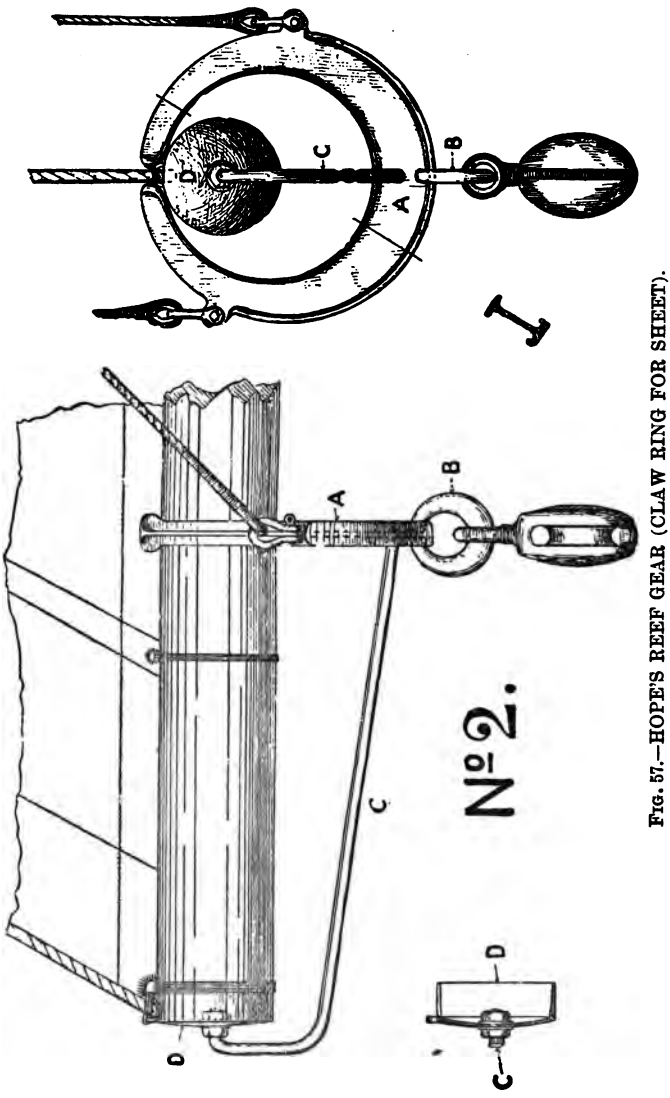


FIG. 57.—HOPE'S REEF GEAR (CLAW RING FOR SHEET).

Roller Reef Gears

single flange and ferrule on the fore end of the boom, with a small line attached to the luff of the sail, or to the boom, and coiled on the latter between the luff and the flange when the sail is not reefed. The roller line is led from the foot of the mast to any convenient spot, and by pulling it, as the halyard is slacked up, the sail is rolled up. The boom being free to turn on the shank of the gooseneck or jaws.

The principal objection to all the foregoing reef gears is, that one hand, at least, is employed in revolving the boom, while the other must be used to ease up the halyards as the sail is rolled; and constant attention is required to see that the luff rope of the sail is coiled fairly on the boom; also that there are no creases along the foot of the sail while rolling. Consequently, to reef when single-handed, the boat must be hove to, with the sail shaking; and little or no strain on the sheet, the result being a tendency to roll in bad wrinkles, and often to roll up the claw ring or topping lifts with the sail. The endless chain gear, which has been in use for many years on some of the channel pilot cutters, pointed out a means of getting over all these objections, though, as they usually fit it, the sail has to be rolled up whenever it is lowered, which is a fatal objection for small craft, which often have to lower in a hurry.

The reef gear, shown in the accompanying illustrations (*see Figs.* 56 and 57), has been designed by the writer, for use either in the smallest single-handers, such as racing canoes (where only one hand can be at liberty, if the boat is to be steered), up to the largest vessels in which fore and aft sails are used, and where the reef line would be taken to a steam or other winch, according to the power required.

It is on the same general principle as the endless chain just described, or as an ordinary roller blind; the whole gear is very light, and can be worked either directly, or by means of a line led to any convenient part of the boat; one end being attached to the roller wire, and the other to the jaws of the gaff.

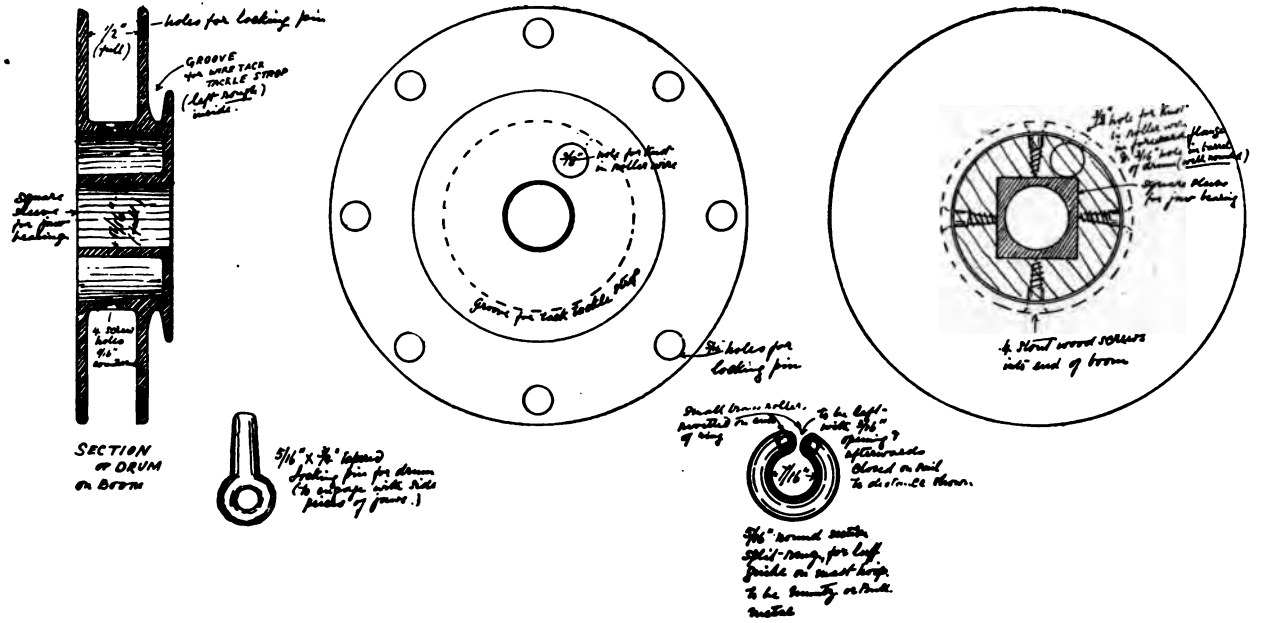

SECTION OF DRUM OR BOOM
GROOVE FOR WIRE TACK TACKLE STROP
Square sleeve for jaw locking
Grooves for cable
Small brass roller, mounted in each end of thing
To be cast with the opening & otherwise closed in sail to distribute thrust.
Wrought metal shackle-strap for tack tackle to be securely riveted

FIG. 58.

In large sizes, this line would be taken to a winch, as previously stated.

Roller Reef Gears

The first illustration (*see Fig.* 56) shows a small size suitable for canoes or dinghies, but the larger sizes are made in a slightly different form, as shown (*see Figs.* 58 and 59). The claw ring (*see Fig.* 57) is of the same pattern in all sizes, with the exception of the rod C, which is double in the larger sizes, and attached to the claw ring at the same points as the topping lifts. In addition to the great strength for weight of this form of claw ring it will be seen that the sheet block is free to travel on the lower rim, and thus is always pulling from the proper part of the ring, no matter what position it may be in; instead of forcing the ring against the sail, as it would if the sheet block were fixed in the center of the ring as usual.

On referring to the illustrations it will be seen that the roller wire, which revolves the boom, is coiled on a drum fixed to the fore end of the spar, and turning freely on the shank of the jaws (or gooseneck, if the latter is preferred). This wire is rove through a flat metal block, shackled to the end of the main, or throat halyard, and attached to the jaws of the gaff; consequently, when the gaff is hauled down, the roller wire is pulled through the block, and unwound off the drum on the boom, which it revolves as it unwinds; the sail being rolled up as the wire is unrolled, or the wire rolled up as the sail is hoisted, according to the direction of the strain on the roller wire. Before rolling, or unrolling the sail, the tension on the luff is relaxed, either by slacking up a trifle on the halyard, or by means of the tack tackle, where one is fitted. The advantage of the latter being that the wire strop of the tack, passing over the V groove, shown on the fore side of the drum, in the larger size, acts as a friction brake when it is set up, and prevents the boom revolving; the locking bolts not being required, except as a stand-by, in case of a breakage.

The luff of the sail is attached to the mast by a lacing, or

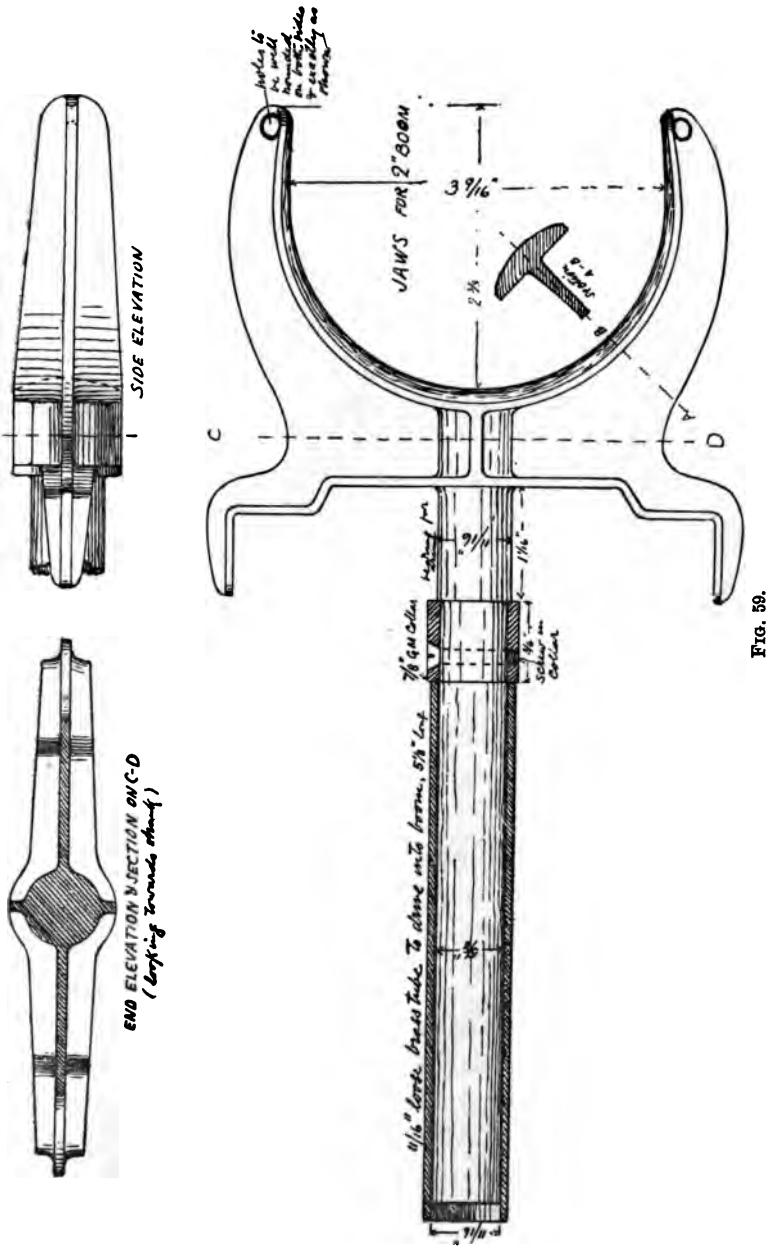

SIDE ELEVATION
END ELEVATION & SECTION ON C-D
(looking towards stern)
JAWS FOR 2" BOOM
3 9/16"
2 3/4"
C
D
A
B
1 1/16" dia. brass tube. To drive into brass, 5/8" long
1 1/16"

FIG. 59.